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Alternative Energetics Of The United States Of America In Global Challenges

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ABSTRACT. In the scientific article we have justified the principles of formation of the energy model of economic development of the United States of America, we have investigated the role, preconditions, factors and mechanisms of the extended implementation of alternative energetics, we have revealed insights into the key areas of achieving national energy security of the United States in the context of global challenges. We have investigated the world energy market, and we have determined the fundamental regularity of its development, which is a multidimensional diversification, as well as global asymmetry in the production and consumption of energy resources with the monopoly of a small group of countries. We have determined cause-and-effect relationships between the energy crisis of the last quarter of the 20th century and the transition of the leading countries of the world to the development of resource-preserving type of social reproduction. We have undertaken a comprehensive analysis of the United States global competitiveness and leadership in the energy sector; we have investigated the structure of the United States energy balance which is characterized by the dominance of traditional energy sources. Now the United States is acquiring more and more features of a self-sufficient country in terms of energy, having received the status of a net exporter of gas and the leader in sales of refined petroleum products. In this article we have assessed the energy policy of the United States, and we have found that the level of energy supplies of the country is the focus of the government policy; this is confirmed by a number of relevant legislative projects that establish energy saving standards and provide for encouragement of alternative energy development. We have determined the compensatory role of alternative energetics on the market of energy resources and in general energy consumption under conditions of global economic security as well as the key factors of its development: significant reduction in the price for energy technologies over time, rising cost of traditional energy sources, increasing level of environmental standards, state support for energy-efficient projects. We have carried out a detailed analysis of the global energy security ranking, and we have identified leading positions of the United States therein; we have established the determinants of the global energy leadership of the United States; we have revealed the imperfection of the method of calculating the energy security index; the following disadvantages of the method of determining the level of energy security should be considered the main ones: failure to consider the level of development of the sector of alternative energy as well as the fact that significant amounts of imported energy, after being processed, are transformed in the export of petroleum products; we have proposed to adjust the methodology of determining the level of energy security by incorporating indicators characterizing the level of development of alternative energy (volumes of introduction of renewable energy sources,

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investment in the development of renewable energy sources) in the calculations, and by replacing the energy resources import volume indicator for the volumes of consumed imported energy resources; we have determined that in the future the energy security of the United States will have persistent moderate trend towards improvement under the influence of close links with a number of factors that are in steady uptrends (development of alternative energy, energy resources export, appreciation of the national currency, global competitiveness).

KEYWORDS. Alternative energy, renewable energy sources, energy security, energy crisis, world energy resources market, global asymmetry, energy balance, energy policy, global challenges.

Introduction

At the present stage of the world economy development, we can observe a growing problem of energy resources availability in national economies which is the key not only to the stable development of the country but also one of the factors of its national security and sovereignty in general. The problem of limited and uneven distribution of energy resources is a global trend of today, and this makes alternative energy development one of the fundamental national interests for many countries of the world.

The works of many foreign and domestic scholars, in particular *A. Ednon*[2], *D. Friedman*[3], *H. Heletukha*[4], *Ya. Stoliarchuk*[5], *D. Sydorova*[6], *A. Kasych*[7], *I. Sotnyk*[8], *A. Dymytrov*[9], *D. Busariev*[10], etc., are dedicated to the study of the role of the energy sector in ensuring the competitiveness of national economies, the effective use of available energy resources and the problems of formation of country's energy balance. The position of the global leader of the United States of America on the world scene depends significantly on the availability of

[2] Amin Adnan. «The Economics of Renewable Energy: Falling Costs and Rising.» The Huffington Post, 2016. http://www.huffingtonpost.com/adnan-z-amin/the-economics-of-renewabl_b_7452996.html.

[3] Friedman, David. «Charts That Show Renewable Energy is on the Rise in America.» Office of Energy Efficiency & Renewable Energy. 2016. https://energy.gov/eere/articles/4-charts-show-renewable-energy-rise-america.

[4] Geletukha, G. G. «Analysis of Energy Strategies of EU and the World as Well as the Role of Renewable Energy Sources.» Analytical Note BAU, no. 13 (2015): 35.

[5] Stolyarchuk, Y. M. «Recent Trends in the Transnationalization of the World Market of Energy Resources.» Economy and Entrepreneurship, 30th ser. (2013).

[6] Sydorova, D. S. «Problems and Prospects of Alternative Energy Development in the World.» In Actual Problems of International Relations: Collection of Scientific Works. Kyiv: Kyiv Taras Shevchenko National University. Institute of International Relations, 2014.

[7] Kasych, A. O. «Alternative Energy: World and Domestic Experience.» Scientific notes of Ostroh Academy National University. 2013.

[8] Sotnyk, I. N. «The Development of Alternative Energy as Part of the US Energy Strategy.» SumDU. www.essuir.sumdu.edu.ua.

[9] Dymytrov, A. A. «Energy Crisis or Future of the Alternative Energy?» Refrigeration Equipment and Technology, no. 4 (2014): 71.

[10] Busariev, D. V. Diversification of the Global Energy Market in the Context of the Global Energy Crisis. PhD's thesis, Kyiv National Economic University Named after Vadym Hetman, 2014. Kyiv: Kyiv National Economic University Named after Vadym Hetman, 2014.

sufficient energy resources, their rational use, and therefore the relevance of the expanded implementation of renewable energy sources in the national economic system increases. In this context, a determinative range of problems is formed by issues of alternative energetics development and efficiency of its implementation as well as deepening study of influencing factors.

Being one of the basic industries of the world economy, energetics has a huge impact on global, political and economic processes, especially given the fact that humanity is still at the stage of developing competitive energy products. Postindustrial countries are significantly dependent on primary hydrocarbon energy resources, and in case of their deficit, there will be a large-scale failure in the modern social and economic system.

Under the conditions of global asymmetry of the location and consumption of energy resources, it is extremely important to reveal the theoretical principles of the formation of the energy model of economic development of the United States of America, to study the role, preconditions, factors and mechanisms of the expanded implementation of alternative energetics and to substantiate the key directions of achieving national energy security of the United States in the context of global challenges.

Alternative energy sources in the country's energy model formation

Availability of energy products is one of the key factors of the problem of energy security which is becoming more acute every year not only at the national but at the global level as well. In view of the imperfections of traditional energy resources and the environmental problem, such developed countries as the United States, Japan, Germany and Denmark in their energy policies pay considerable attention to the development of the alternative sector of energetics and plan to increase the part of the renewable energy sources in the overall energy balance to 20-50%[11].

Renewable energy is energy from sources that are inexhaustible on a human scale, that is, energy from the sun, wind, geothermal, hydropower and ocean resources as well as solid biomass, biogas and liquid biofuel. Furthermore, operating costs for the use of non-traditional sources do not contain a fuel component since the energy of these sources is formally free[12].

[11] Sydorova, D. S. «Problems and Prospects of Alternative Energy Development in the World.» In Actual Problems of International Relations: Collection of Scientific Works. Kyiv: Kyiv Taras Shevchenko National University. Institute of International Relations, 2014.

[12] «Alternative Energy in the USA Is a Subsidy Industry – Experts.» Voice of America. 2013. http://ukrainian.voanews.com/a/wind-power-tax/1666267.html.

In particular, the renewable energetics sector is developing under the influence of such events as a sharp decline in world prices for fossil fuels and renewable energy under long-term contracts and growing attention to energy saving among countries around the world. In 2015, the installed capacity of renewable energy sources (RES) was approximately 29% of the world's generating capacity[13]. However, the implementation of RES requires substantial investment, appropriate and favorable legislative framework, public awareness of this need. Therefore, large-scale energy projects, such as construction of solar and wind power plants, can be implemented with state support through international cooperation. Thus, the United Nations declared the decade 2014–2024 as the Decade of Sustainable Energy for All (UN, 2015). The production of alternative energy is growing annually by 2.5%, but this is not enough to meet the demand in a timely manner[14].

Since the development of alternative energetics is a priority, the International Renewable Energy Agency (IRENA) has developed a roadmap to double the share of renewable energy in the world energy consumption in the 2010-2030 period (REmap 2030): from 18% of RES in total final energy consumption (2010) to 36% (2030)[15]. Furthermore, today there are about 148 planned and already implemented projects of several categories (urban, regional, state, housing fund, business) in the world related to the replacement of the use of fossil fuels and the complete transition to renewable energy[16].

It should be noted that the renewable energy and energy efficiency sector plays a significant role in the formation of the energy model of the EU countries. It became one of 11 investment priorities of the new budget of the European Regional Development Fund (ERDF) for 2014-2020. Since 2014, all the EU regions have concentrated most of the assignments on innovative energy and economic sectors, and about 20% of investment projects are aimed at the development of energy-efficient technologies and alternative energetics[17]. In particular, Germany recognizes the prospects of alternative energy sources and plans to switch to RES completely by 2050. Lower Austria declares the refusal to use coal-fired power plants as HPPs meet their energy needs. Iceland, Paraguay and Norway meet domestic needs at the expense of RES

[13] Markevych, K. «Global Energy Trends through the Prism of Ukraine's National Interests.» In Analytical Report. Kyiv: Zapovit, 2016.

[14] Kochtcheeva, Lada. «Renewable Energy: Global Challenges.» E-International Relations. 2016. http://www.e-ir.info/2016/05/27/renewable-energy-global-challenges/.

[15] Geletukha, G. G. «Analysis of Energy Strategies of EU and the World as Well as the Role of Renewable Energy Sources.» Analytical Note BAU, no. 13 (2015): 35.

[16] Ibid, p. 8.

[17] Sydorova, D. S. «Problems and Prospects of Alternative Energy Development in the World.» In Actual Problems of International Relations: Collection of Scientific Works. Kyiv: Kyiv Taras Shevchenko National University. Institute of International Relations, 2014.

remaining the largest exporters of oil and gas[18]. Denmark, in turn, satisfies 140% of its needs using wind energy[19].

Shale gas has recently become very popular in the United States, however, alternative energetics is being actively developed as well: almost 50% of the energy produced in 2014 was solar and wind energy. This industry has reached such level of development due to state support and mandatory in certain regions condition to use alternative energy sources partially[20].

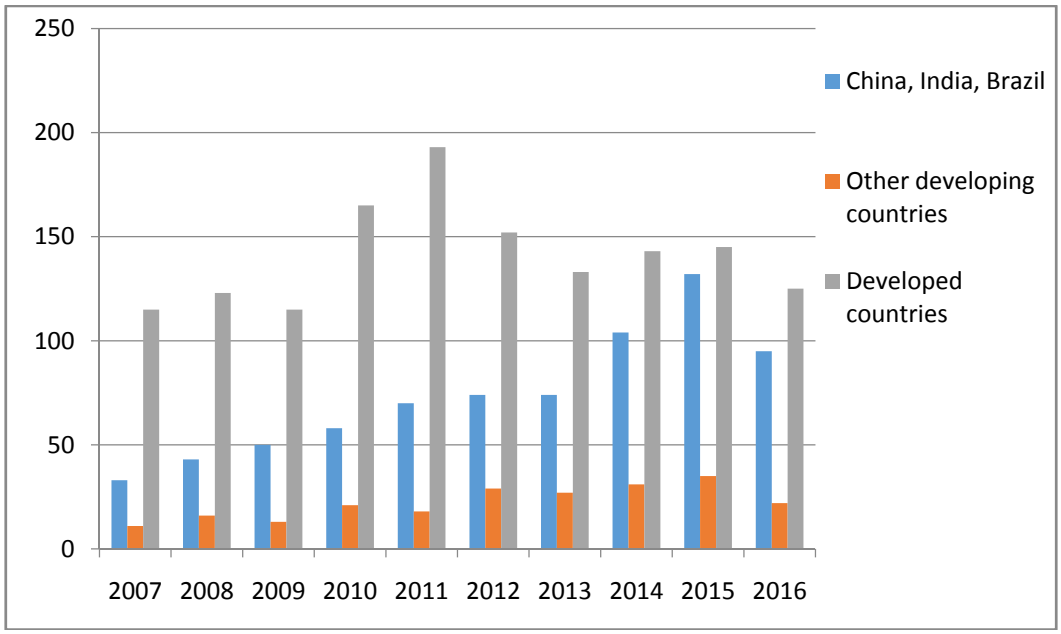

Fig. 1. Dynamics of global investment in renewable energy sources by the type of economy, billion USA[21]

China also shows a significant interest in strengthening the role of RES in the energy model, increasing its capacity through the construction of wind and solar power plants and HPPs (55%)[22]. In

[18] Romaniuk, V. «The Price Is below Zero. The Alternative Energy Is Finally Beginning to Win.» NewsMarket. 2016. http://www.newsmarket.com.ua/2016/06/tsina-nizhche-nulya-alternativna-energetika-nareshti-pochinaye-peremagati/.

[19] William, Jacob. «Renewable Resources: The Impact of Green Energy on the Economy.» Business.com. 2015. http://www.business.com/entrepreneurship/the-impact-of-green-energy-on-the-economy/.

[20] «Alternative Energy in the USA Is a Subsidy Industry – Experts.» Voice of America. 2013. http://ukrainian.voanews.com/a/wind-power-tax/1666267.html.

[21] plotted by the authors according to information from Markevych, K. and V. Omelchenko Global energy trends through the prism of national interests of Ukraine. Analytical report Kyiv: Zapovit, 2016: 51.

[22] Geletukha, G. G. «Analysis of Energy Strategies of EU and the World as Well as the Role of Renewable Energy Sources.» Analytical Note BAU, no. 13 (2015): 23.

addition, small countries are making significant progress in the development of alternative energetics. Costa Rica, having refused to import fossil fuels, was using only RES at 100% for 75 consecutive days for the first time in the world[23]. Interest of the countries of the world in the development of alternative energetics is confirmed by the levels of investment in renewable energy sources (Figure 1).

However, there are some obstacles to the comprehensive development of RES, such as insufficient encouragement of the private sector to finance and develop such sources as well as support and subsidization of fossil fuels extraction. The growing threats to energy security and independence are leading countries to develop and use more intensively alternative, renewable energy sources which have a number of economic advantages and play a significant role in the further formation of their energy models.

Alternative Energetics as a Component of the Energy Policy of the United States of America

In the context of globalization of the world economy, resources availability and the level of efficiency and rationality of their use have a significant impact on the geopolitical role of the country. This is particularly true of energy products which represent an integral factor for the preservation of the leading position of the United States of America (Figure 2).

The economic potential of the United States is extremely powerful because it has a huge domestic market (4% of the world population) which consumes 40% of the world product. The United States accounts for less than 2% of the world's oil reserves but more than 20% of its global consumption as well as 20% of electricity consumption[24]. The basis of the United States energy model is formed by consumption of not only petroleum products but also natural gas, coal, nuclear energy, biofuel, hydropower and renewable energy products.

Having analyzed trends of the use of various energy resources, we can say that production of natural gas and petroleum products, 45% of which are related to shale oil, reaches the largest volumes. There is a tendency towards increasing role of RES along with a decreasing coal production. Cheap shale gas can even displace natural gas, the production of which is becoming more expensive in the United States. It should be noted that shale gas production has made a real revolution in the energetics of the United States, its exports to South America, Europe, India and China increased in 2016. This tendency is also explained by Europe's dependence on Russian gas. All this allowed

[23] «The Transition to Alternative Energy Becomes Profitable.» Ukrainian Association for Renewable Energy. http://uare.com.ua/novyny/385-perekhid-na-alternativnu-energetiku-stae-rentabelnim.html.

[24] Sotnyk, I. N. «The Development of Alternative Energy as Part of the US Energy Strategy.» SumDU. www.essuir.sumdu.edu.ua.

the United States to respond more quickly to changes in OPEC oil prices and oil production volumes[25].

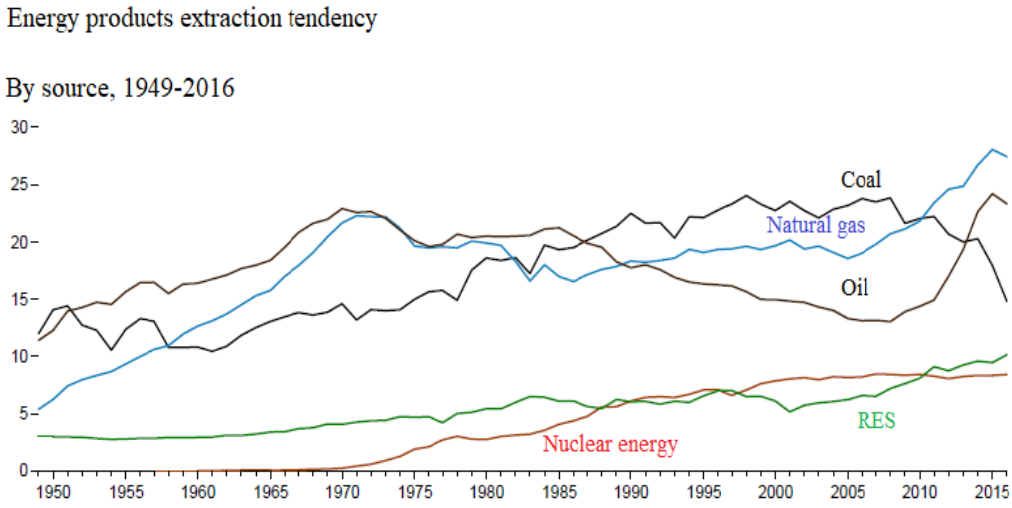

Fig. 2.a.

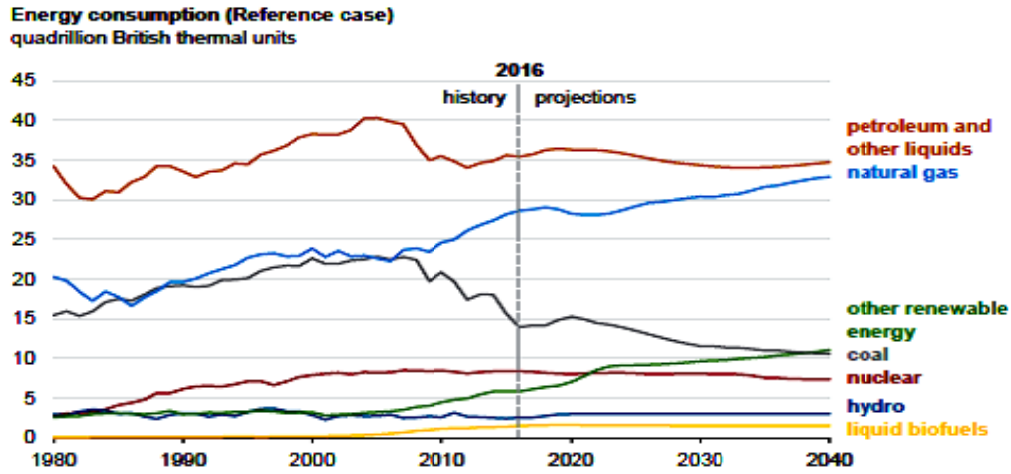

Fig. 2.b.

Fig. 2. Current trends in production and consumption of energy products in the United States[26]

[25] Bordoff, Jason. «America's Energy Policy – From Independence to Interdependence.» Center for International Relations and Sustainable Development. 2016. https://www.cirsd.org/en/horizons/horizons-autumn-2016--issue-no-8/americas-energy-policy-from-independence-to-interdependence.

The United States became the first country in the world which acquired almost all the features of a self-sufficient country in terms of energy, while new technologies pushed its oil market to leadership on a global scale. Over the past 10 years, the import dependence of the United States has fallen by 60% and now this country is the largest exporter of refined petroleum products, and in 2016-2017 it became a net exporter of natural gas[27]. Brookings Institute research shows that the growth of crude oil exports will have a positive impact on both the US and global markets. Provided that the ban on oil exports is lifted, GDP will increase by almost USD 600,000,000. However, European partners cannot rely only on their supplies because American companies need to agree on prices with OPEC[28]. The main objective of the growth of energy independence is to reduce the sensitivity to shifts in supply and prices as well as to be able to achieve its own geopolitical goals. The decline in the coal industry is associated with many economic, social, political and environmental factors. Its main reason consists in the replacement by relatively cheap shale gas and RES. BNEF analysts argue that the shifts that occurred in 2015 are not an accident but rather evidence of structural movement in the energy sector. Thus, we can observe a gradual «decarbonization» of the United States energy sector[29].

The nuclear power sector is quite significant, although its share in the energy structure is relatively low and the pace of exploitation remains stable. However, the United States is the largest nuclear power producer in the world with a share of more than 30% which has a significant part of the world's uranium reserves.

The role of alternative energy sources in the economy of the United States deserves particular attention. In particular, it accounts for about 10% of total energy consumption and 15% of electricity production. While hydropower industry is the largest renewable energy source in the United States, geothermal energy constitutes only about 0.5% of total electricity. Consumption of biofuel and other alternative energy sources more than doubled during 2000–2015 mainly through state and federal incentives[30].

The use of cheap and excess hydrocarbon raw materials creates a chance for more dynamic economic development of the United States. Thus, according to Cambridge Energy Research Associates (IHS CERA), the development of shale oil and gas resources has created 2.5 million new jobs

[26] «U.S. Energy Information Administration.» http://www.eia.gov; «Annual Energy Outlook 2017.» https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf.

[27] Sieminski, A. «U.S. Oil in the Global Economy.» Center for Strategic and International Studies. 2017. https://www.csis.org/features/us-oil-global-economy.

[28] Sergie, Mohammed. «U.S. Energy Exports.» Council on Foreign Relations. 2014. https://www.cfr.org/backgrounder/us-energy-exports.

[29] Freedman, Andrew. «The renewable energy revolution is already upon us, report shows.» Mashable. 2016. http://mashable.com/2016/02/04/renewable-energy-revolution/#8fM.zfrCxSqq.

[30] «Annual Energy Outlook 2017.» https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf.

and added USD 100 billion to the budgets of all levels[31]. The United States also had the opportunity to reduce its dependence on politically unstable countries, such as Egypt, Algeria and Nigeria. The United States government is working to increase gas exports to Japan, India, and Eastern Europe and is sharing its experience in alternative energy development with Poland, Ukraine, Jordan, China, Colombia, Chile and Mexico[32]. In general, the United States energy market is characterized by increasing consumption of petroleum products, natural and shale gas, which is due to the increased needs of the economy. Therefore, we can say that the dominance of organic energy resources and increasing share of RES, which are gradually replacing coal on the market, are peculiar to the United States energy model.

Compensatory role of alternative energetics in the economic security of the United States

Despite the reduction in the emphasis of the Presidential Administration on the importance of alternative energetics, this industry still continues to develop because it is quite attractive and promising for investment and still remains subsidized in the United States. RES have been recognized as an effective source of electricity generation by the aid of states with appropriate climatic conditions. Thus, according to the Energy Information Administration (EIA)[33], the share of RES consumption in the total energy balance of the United States is 20.66%, which exceeds the consumption of nuclear energy (9.12%) and is rapidly approaching the share of coal-fired power plants (23.04%) in the total consumption of energy resources in the country. Besides, hydropower industry, energy from wood waste and biofuel production predominate. Scientific and technological progress has a significant influence on strengthening the position of this type of fuel due to reduction of its cost and tax benefits. The United States is a leader in the field of geothermal energetics having the most considerable resources of this energy in the world. At the end of 2015, installed capacity of GeoPPs was 3.567 GW or 29% of the total world capacity[34].

It should be noted that the United States is also strengthening its position among the leaders of the use of solar energy by reducing its cost and preferential incentive programs for the population[35]. The

[31] Markevych, K. and V. Omelchenko Global energy trends through the prism of national interests of Ukraine. Analytical report Kyiv: Zapovit, 2016: 95.
[32] Donilon, Tom. «Energy and American Power.» Council on Foreign Relations. 2013. https://www.foreignaffairs.com/articles/united-states/2013-06-15/energy-and-american-power.
[33] «U.S. Renewable Energy Factsheet.» Center For Sustainable Systems. http://www.css.snre.umich.edu/factsheets/us-renewable-energy-factsheet.
[34] «Annual Energy Outlook 2017.» https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf.
[35] Kasych, A. O. «Alternative Energy: World and Domestic Experience.» Scientific notes of Ostroh Academy National University. 2013.

leaders of solar energetics are five states which account for 81% of all installed capacities of SPPs: California, Arizona, South Carolina, Massachusetts and New Jersey. According to experts, the United States became the leader of the world wind energetics – 21% of the use of all RES (Figure 3). At the same time, the growth of alternative energy production for 2015–2020 is expected to be within 24–35%[36]. Thus, according to the United States Energy Information Administration, in 2014 the use of RES exceeded the amount of electricity generated at hydroelectric power plants[37].

In particular, MidAmerican Energy has invested more than USD 15 billion in projects on alternative energetics[38]. In addition, it is possible to trace the growth of financial assets of enterprises developing projects with the use of RES by 31% to USD 24.4 billion on the basis of Renewables 2016 Global Status Report[39]. In recent years, there has been a rapid increase in consumption of energy from renewable sources (Figure 3).

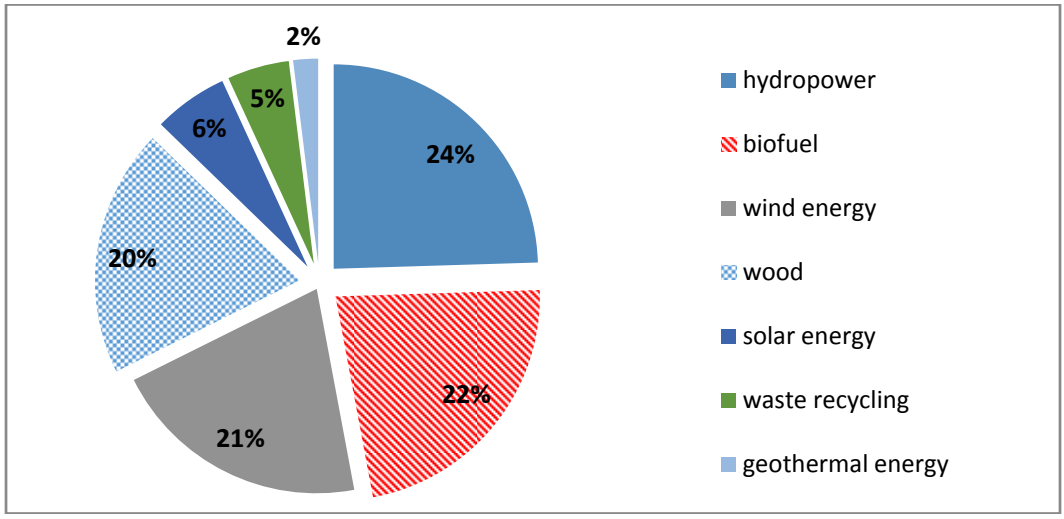

Fig. 3. Structure of the United States renewable energy sources use, 2016[40]

[36] Romaniuk, V. «The Price Is below Zero. The Alternative Energy Is Finally Beginning to Win.» NewsMarket. 2016. http://www.newsmarket.com.ua/2016/06/tsina-nizhche-nulya-alternativna-energetika-nareshti-pochinaye-peremagati/.

[37] «How much U.S. electricity is generated from renewable energy?» U.S. Energy Information Administration. http://www.eia.gov/energy_in_brief/article/renewable_electricity.cfm.

[38] Hulac, Benjamin. «Strong Future Forecast for Renewable Energy.» Scientific American. 2015. https://www.scientificamerican.com/article/strong-future-forecast-for-renewable-energy/.

[39] «Renewable Electricity Standards Deliver Economic Benefits.» Union of Concerned Scientists. 2013. http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/renewable-energy-electricity-standards-economic-benefits.html.

[40] plotted by the authors according to information from U.S. Energy Information Administration. http://www.eia.gov.

The important role of alternative energetics in the functioning of the United States economy is evidenced by the growth of venture capital and other private investment in RES by USD 2.2 billion in 2015 (Figures 4–5).

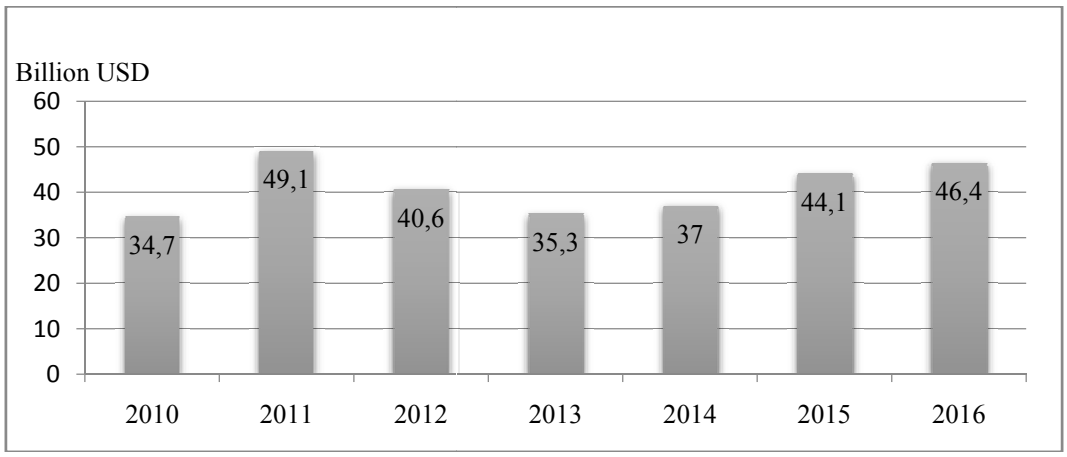

Fig. 4. Dynamics of investment in RES in the United States of America[41]

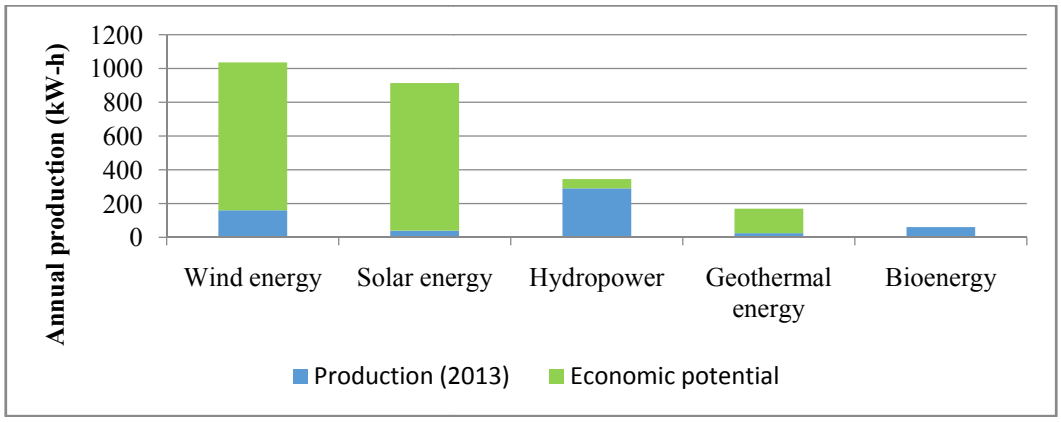

Fig. 5. Assessment of the RES development potential in the United States[42]

[41] plotted by the authors according to «Annual Energy Outlook 2017.» https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf.

[42] plotted by the authors according to «Estimating Renewable Energy Economic Potential in the United States: Methodology and Initial Results.» NREL. www.nrel.gov/publications.

The main feature of the United States energy model is a significant share of hydrocarbon energy products. Given the threat of the depletion thereof, D. Trump's predecessors introduced a number of federal incentives, such as tax credits, grants and subsidies for RES consumers, and alternative energy producers sell Renewable Energy Certificates to consumers, which will allow them to save money in the future compensating for current consumption costs[43].

It is worth noting that one of the main reasons for the development of alternative energetics in the United States is not only the achievement of energy independence, but also competition with China, whose economic growth rates are extremely high and its connection with the economy of the United States is quite strong. Since China is one of the leaders in the development of alternative energetics, the United States is trying to maintain its leading position in the energy market[44]. Simultaneously with the expanded use of RES, it has the opportunity to use its shale gas reserves which is one of the strategic priorities in the confrontation with the Russian Federation in the geopolitical space. Close cooperation between the United States and Canada in the energy sector has allowed the North America region to turn from a leader in consumption into a leader in natural gas production[45]. Another reason for energy independence accession is the desire to reduce political and economic dependence on energy-exporting countries and their influence on international policies and the manipulation of their buyers[46].

By replacing primary energy resources with alternative ones, the United States has the opportunity to increase oil and gas exports and thus support the dollar exchange rate. One possible instrument for achieving this goal is a proposal for tax reform: the introduction of a corporate tax which shall be adjusted at the border subject to the destination country; it consists in the absence of export tax and the introduction of the 20% tax on imported goods and services. Appreciation of the dollar, which should grow by 25% as a result, shall compensate for the 20% tax paid by importers[47]. Based on the above, it can be argued that the development of alternative energetics is the guarantor of independence and prosperity of the United States, as it was able to allocate a sufficient amount of financial and material resources for the development of RES.

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[43] U.S. Renewable Energy Factsheet. Center For Sustainable Systems http://www.css.snre.umich.edu/factsheets/us-renewable-energy-factsheet

[44] Steeves, B. B. «Energy Security: China and the United States and the Divergence in Renewable Energy.» Contexto Internacional., vol. 38 (2016).

[45] Kobelek, M. L. «Shale Gas in the United States: Transforming Energy Security in the Twenty-first Century.» NORTEAMÉRICA., no. 1 (2015).

[46] Deni, John R. «New Realities: Energy Security in the 2010s and Implications for the U.S. Military.» 2015.

[47] Sieminski, A. «U.S. Oil in the Global Economy.» Center for Strategic and International Studies. 2017. https://www.csis.org/features/us-oil-global-economy.

Assessment of the economic effect of alternative energetics in the context of energy security of the United States

The sphere of alternative energetics of the United States has extremely great potential. It can solve not only the environmental problem but also the economic and energy security problem of the country. The needs of the growing economy require more and more energy resources and alternative energetics can meet them not only in environmentally friendly but also in economically advantageous manner. Therefore, it is advisable to determine the effects of the expanded implementation of RES in the United States.

Having studied the tendencies in the global energy market, the International Energy Agency reported on the economic competitiveness of wind and solar energy production in certain regions of the United States. The main cause consists in a significant government support of this industry, namely the 30% tax credit for solar energy producers, and falls in prices over time and increase in the usage peculiar to technologies. According to analysts of Deutsche Bank, over the next two years, the use of RES will become more profitable than traditional energy sources in 47 states due to the continuing fall in the cost[48].

The possibility to create new jobs in the country is even better prospect for maximizing the positive economic impact of alternative energy sources. While the world is recovering from the economic crisis, the problem of unemployment is quite acute. World leaders, including the relevant authorities in the United States, are increasingly focused on engaging the maximum number of persons in the sphere of production of energy from renewable sources. This policy provides for the regulation of development, trade, investment, scientific research and provision of education in the field of RES development. It should be noted that according to the report for 2016 of the International Renewable Energy Agency (IRENA), about 769,000 persons work in the alternative energetics sector in the United States[49]. According to the Solar Foundation, in the last 5 years the number of workers employed in the solar energetics industry has increased by 86%. This tendency is the result of the fall in the cost of RES use and the example of the so-called «closed circle» (a repetitive cycle of events, each of which results in an increase of the positive effect). Which is the complete opposite of the «vicious circle» of the oil industry where high production results lead to falling prices causing massive layoffs[50].

[48] Lohan, Tara. «The Big Reason Why America Is Turning to Renewable Energy.» Alternet. 2015. http://www.alternet.org/environment/americans-are-switching-renewable-energy-because-its-cheaper.
Sotnyk, I. N. «The Development of Alternative Energy as Part of the US Energy Strategy.» SumDU. www.essuir.sumdu.edu.ua.
[49] «U.S. Energy Information Administration.» http://www.eia.gov.
[50] Kochtcheeva, Lada. «Renewable Energy: Global Challenges.» E-International Relations. 2016. http://www.e-ir.info/2016/05/27/renewable-energy-global-challenges/.

The development of alternative energetics contributes to the improvement of the investment climate in the United States and is accompanied by a flow of new investments in the economy, and in 2016 such investments amounted to USD 46.4 billion[51]. The positive impact of alternative energetics on infrastructure and the local economy deserves attention as well. The owner of private land usually receives payments in the form of rent, royalties or other regular payments for the installation of wind turbines thereon. In addition, the implementation of such energy projects is accompanied by additional revenues to the budget of both state and local authorities in the form of income taxes and rental fees. Increasing the use of RES helps to stabilize electricity prices and ensure long-term savings. «Fuel» is free after the installation of the power generation facility. Fossil fuel prices are often volatile, which can lead to significant fluctuations in electricity prices[52].

From the point of view of environmental safety, the current public and private investments in alternative energetics development with the aim of increasing their share in the energy structure of the United States help to save on future addressing the consequences of environmental pollution. It is worth noting that the United States largely subsidizes its ethanol industry by providing tax discounts to oil refining companies which mix ethanol with petrol. However, experts believe that significant technological innovations will be needed to make ethanol production more efficient.

In general, according to a new report by the International Renewable Energy Agency (IRENA), the sustainable introduction of renewable energy sources creates jobs, increases revenues, improves the trade balance and contributes to industrial development[53].

Given the leading position of the United States on the world scene, it is necessary to clearly understand the challenges and threats to national security. That is why we have studied a number of factors that determine energy and economic security, which made it possible to determine the role of alternative energetics in maintaining stability and security.

The study of the energy security index of the United States, developed by the Global Energy Institute at the Chamber of Commerce of the United States, suggests a gradual decrease in its level, especially since 2011 (Figure 6). The main reasons for this trend were the decline in export prices for oil, growth in imports of oil and natural gas, high

[51] «Annual Energy Outlook 2017.» https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf.

[52] «Renewable Electricity Standards Deliver Economic Benefits.» Union of Concerned Scientists. 2013. http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/renewable-energy-electricity-standards-economic-benefits.html.

[53] Hower, Mike. «Renewable Energy Can Lead to Economic Boom, Report Finds.» TriplePundit. 2014. http://www.triplepundit.com/2014/06/renewable-energy-can-lead-economic-boom-report-finds/.

energy consumption of households as well as carbon dioxide emissions into the atmosphere.

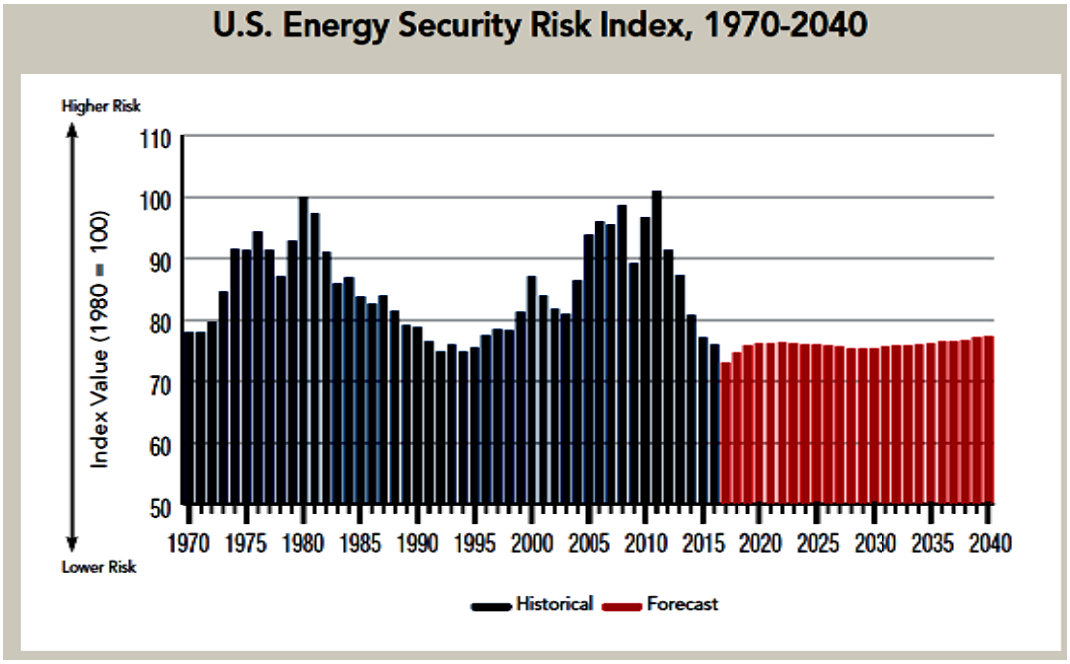

Fig. 6. Dynamics of the energy security of the United States, 1970–2040[54]

We have revealed such a paradox: in parallel with the decrease in energy security, the United States has become a net exporter of gas and one of the leaders in the production and export of petroleum products. At the same time, the production and consumption of RES reached 10%. We have analyzed the methodology of calculating the energy security index of the United States, and we have found that it consists of 4 subindexes with a certain weight: geopolitical (30%), economic (30%), reliability (20%) and environment (20%)[55]. In other words, it is complex and includes a number of other indicators of the state of energy security without RES production and consumption, which today is an important component of the energy security of the country. This fact today is a significant drawback of this methodology. The main reason for ignoring this indicator is the requirement to comply with the principles of the methodology under study, one of which is completeness

[54] «U.S. Energy Security Risk Index.» Global Energy Institute. 2017. https://www.globalenergyinstitute.org/energy-security-risk-index.
[55] «U.S. Energy Security Risk Index.» Global Energy Institute. 2017. https://www.globalenergyinstitute.org/energy-security-risk-index.

(data since 1970 should be available). Since alternative energetics is a relatively young phenomenon, the inclusion of information on its consumption is not provided for in this methodology.

To determine the relationship between the consumption of alternative energetics and energy security state, we have calculated a number of indicators using MS Excel and SPSS software packages, in particular the correlation coefficient which, with the value of -0.71, showed that there is a significant feedback between these phenomena. Calculations of intermediate parameters are presented in Annex 1.

However, this result may be a consequence of another drawback of the methodology under study as it takes into consideration only energy resources import and ignores exports thereof. Further study of the influence of energy resources exports on the level of energy security of the United States makes it possible to state that there is a close feedback between energy security and energy resources exports with a correlation coefficient of −0.73 (Annex 2), that is with an increase in energy resources exports, the level of energy security decreases, but at the same time there is a direct relationship between RES consumption and energy resources exports with a correlation coefficient of 0.96 (Annex 3). This analysis leads to the conclusion that the United States, developing alternative energy for its own consumption, increases the export of processed traditional energy sources (such as petrol) instead, which ultimately leads to an increase of the energy security of the country and an increase of influence in the international scene. It is known that the United States is not only one of the main consumers of oil and gas but also one of the exporters of refined petroleum products. Thus, we can conclude that a significant share of oil imports is intended for processing and further resale abroad. Given the above-mentioned proposal to replace export taxation by imposing special import duties and the appreciation of the United States dollar, we can assume that the main purpose of such energy policy of the United States is to stabilize the exchange rate of the national currency by increasing the exports of refined petroleum products and shale gas. So the main motive for the rapid development of alternative energetics in the United States is a compensation for the export of traditional energy resources and products of their processing. RES consumption has a positive influence on the energy intensity of GDP as well (inverse dependence, correlation coefficient -0.92), which in turn has a positive effect on the state of energy security with a correlation coefficient of 0.80 (Annexes 4-5).

In addition, we have calculated energy security elasticity coefficient to the level of energy intensity of the United States GDP, and it showed that with a decrease in the GDP energy intensity index by 1%,

the United States energy security index will grow by an average of 1.13% (Annex 6).

Further calculations of energy security elasticity to a number of factors (Annex 7) revealed the following:

- with an increase in the consumption of alternative energetics by 1%, the energy security index will increase by an average of 0.66%;
- with the growth of energy resources exports by 1%, the energy security index will decrease by an average of 0.21%;
- with appreciation of the dollar by 1%, the energy security index will decrease by an average of 0.68%;
- with the increase in global competitiveness indicator by 1%, energy security index will decrease by an average of 1.14%.

All these calculations indicate the imperfection of the existing methodology of determining the level of energy security of the United States and show that it does not reflect the existing reality. It is interesting that according to the forecast of the state of energy security of the Global Energy Institute at the United States Chamber of Commerce for 2017–2040, this index will grow despite the previous 5-year decline. In accordance with the justification of the researchers, the main reason for the positive forecast is the improvement of 18 indicators, which include a decrease in energy resources imports due to an increase in domestic production; an increase in energy consumption efficiency by 35–40% between 2016 and 2040; a decrease in the volume of fuel used by transport; a mitigation of the risks of rising prices for petroleum products by reducing demand from the transport sector.

In general, alternative energetics plays an extremely important role not only in environmental protection but also in maintaining proper level of both energy and, in turn, economic security of the United States of America. Thus, it has the opportunity not only to develop a new energy supply system for the future but also to maintain its influence and leading positions in the global market.

Prospects for the expanded implementation of alternative energy sources in the context of energy security

Given a number of economic benefits from the expanded implementation of RES in mass use, a number of experts believe that this is the key to the economic stability of the country. The future of alternative energetics of the United States will be determined by the interaction of a number of factors: changes in the vector of energy policy, the pace of scientific and technological progress, the dynamics of oil and natural gas prices, achievements in energy savings.

Now there is a clear tendency towards increasing the role of RES both in the structure of energy products consumption and in the interests of the government and private companies. The prospects for success are evidenced by federal tax benefits for subsidizing the production of this type of energy. An example is IDP Renewables, the third largest wind energy supplier in the United States, which claims that «subsidies not only promote the development of alternative energy sources but also allow us to successfully compete with power plants operating on traditional energy sources, such as coal and gas»[56]. In addition, the United States authorities create favorable conditions for residents switching to alternative energy sources. Among them, 30% are tax benefits for those who install a solar-powered electricity system in their homes. The cost of this plan in the next 10 years shall be a little more than USD 1 billion. It is also planned to use more than 280 thousand acres of state land for the construction of high-power solar-power plants. The United States government has already allocated 17 zones in six states with the total area of more than 285 thousand acres. According to experts, states like Utah, Arizona, Colorado, Nevada, New Mexico and California are best suited for this purpose. Most of the land allocated for solar panels is located in Southern California (more than 153 thousand acres)[57].

The United States Department of Environment supports a number of projects aimed at providing people with «green» energy. Local communities and administrative bodies of mega-cities and smaller settlements are the main initiators of these programs. Thus, the authorities of San Francisco planned 100% transition to RES by 2025. To implement this plan, they adopted a bill requiring installing solar panels on all new residential or commercial buildings. The authors of the project argue that it will help to increase the energy capacity by a third providing the necessary amount of resource for more than 2 thousand houses. Although these forecasts seem insignificant at the city level, they show a positive tendency towards geographical spread of RES[58]. Opportunities for alternative energy sources projects exist throughout the United States.

Geothermal heat pumps can make economic sense almost anywhere where land and local development conditions are suitable for it. And the western part of the United States has a high potential for the implementation of projects for the extraction of energy from wind, water and sun[59].

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[56] «Alternative Energy in the USA Is a Subsidy Industry – Experts.» Voice of America. 2013. http://ukrainian.voanews.com/a/wind-power-tax/1666267.html.

[57] Sotnyk, I. N. «The Development of Alternative Energy as Part of the US Energy Strategy.» SumDU. www.essuir.sumdu.edu.ua.

[58] Blokhin, Y. «US and Alternative Energy: A New Vision of Energy in the Legislation.» Energy of Nature. 2016. http://alternative-energy.com.ua

[59] «Trends in Renewable Energy Production and Consumption in the USA.» Geology.com. http://geology.com/articles/renewable-energy-trends/.

Now Hawaii, being a state that depends on fossil fuels most of all in the United States, has opted for a transition to RES in electricity production. The preference is stated for wind, solar and geothermal energy. The state government declares the mandatory introduction of a 100% «green» electricity in 2045, however, the representatives of the organization Blue Planet Foundation (BPF) believe that Hawaii has every chance to achieve this goal already in 2030. Cities like San Diego, Palo Alto, Georgetown, Ithaca, San Jose and Greensburg are also planning to switch to RES in the near future, as evidenced by a number of adopted programs[60].

In general, the extent of future implementation of RES largely depends on both state and people's support. In fact, there are opponents of «green» energetics, motivated by certain beliefs or personal financial interests, along with the supporters thereof. The American Legislative Council (ALEC), a conservative group, opposes the introduction of state standards for renewable energy sources. Utility services companies, such as Pella Electric Cooperative in Iowa and Arizona Public Service in Arizona, are also particularly resisting, as they are purposefully raising tariffs for homeowners who install solar and wind systems to produce electricity[61].

It is also thought that the moderate growth of electricity demand in the country and high competition from relatively cheap natural and shale gas and oil constitute a significant obstacle to the expanded implementation of alternative energetics. However, analysts of the American Investment Bank Citigroup refute the belief that low oil prices have a negative impact on the RES implementation, as the combination «economic competitiveness – energy security – environmental goals» will lead to a rapid increase in global demand for alternative energetics.

According to research by Mark Z. Jacobson, Stanford Professor of Civil and Environmental Engineering, regarding the state-by-state volume and structure of energy consumption, there is a possibility of transition of the whole country to 80% use of RES by 2030 with the prospect of 100% transition until 2050. In particular, on the basis of his analysis, he developed individual plans for the transition to alternative energetics for each state taking into account individual economic and geographical features[62].

The International Electrotechnical Commission studied the concept of GEI (Global energy interconnection) which is the final stage of the natural progress of electric networks aimed at interconnection: a globally interconnected energy system supported by the Smart Grid

[60] Geletukha, G. G. «Analysis of Energy Strategies of EU and the World as Well as the Role of Renewable Energy Sources.» Analytical Note BAU, no. 13 (2015): 35.
[61] Kennedy, Kit. «Trump's «America First» Energy Plan Actually Leaves America Behind.» CleanTechnica. 2017. https://cleantechnica.com/2017/01/30/trumps-america-first-energy-plan-actually-leaves-america-behind/.
[62] Carey, Bjorn. «Stanford Engineers Develop State-by-state Plan to Convert U.S. to 100% Clean, Renewable Energy by 2050.» The Solutions Project. http://thesolutionsproject.org/resource/816/.

infrastructure, and the optimal use of UHV technology for energy transmission over long distances. Such large-scale energy networks will be the basis for the widespread deployment of clean energy which will ensure the proper distribution of power plants where the best resources are located. The international community has already implemented a number of steps towards implementation of this concept, in particular the project of the European super networks, Desertec, Medgrid, Gobitec and Asian Super Gridb, has been launched[63].

It is appropriate to focus on the fact that today it is necessary to pay more attention to the development of alternative energetics in Ukraine. In fact, despite the reduction in the share of natural gas in the structure of consumption, it is still quite large in comparison with renewable energy sources which do not exceed 2% of the general energy consumption, which is an immediate threat to the energy security of the country.

However, it is possible to gain greater energy independence due to the radical technological modernization of the economy, the implementation of various projects to diversify energy resources consumption and the development of alternative energetics. Therefore, Ukraine should pay attention to the establishment of domestic production of biofuel, extraction of shale gas, the development of renewable energy sources by attracting private investment, the introduction of state projects to support alternative energetics and, as a consequence, the improvement of the country's energy security[64].

We have analyzed a number of economic and social consequences of the introduction of alternative energetics at the national and local levels, and we can conclude that it has an extremely strong potential for development in the United States. In particular, this is evidenced by the investors and local authorities supporting numerous «green» projects that can not only stimulate the economy, increase revenues and improve the trade balance but also help the United States to become a more energy independent and clean country.

Conclusion

Summarizing the above, we can formulate a number of conclusions of theoretical and practical significance:

1. Global competitiveness and leadership of the United States in the energy sector are supported by a significant share of the world's oil refining capacity (about 20% of the world capacity) and an increase in

[63] «Global Energy Interconnection.» International Electrotechnical Commission (Geneva), 2016.

[64] Busariev, D. V. Diversification of the Global Energy Market in the Context of the Global Energy Crisis. PhD's thesis, Kyiv National Economic University Named after Vadym Hetman, 2014. Kyiv: Kyiv National Economic University Named after Vadym Hetman, 2014.

energy resources exports (6.3% and 5.9% of the world gas and oil exports, respectively). In the event of increased political and economic instability in the Middle East and Eastern Europe, in the near future the United States will be able to significantly weaken the position of its competitors, the Russian Federation, OPEC and Persian Gulf countries, which supply energy products to Europe, to increase its revenues and strengthen control over the economy of the EU countries not only through traditional finance and investment, innovation and technology channels, but also in the energy sector.

2. Alternative energetics is currently the most dynamic segment of the world energy market which plays a compensatory role in energy consumption in the context of global energy challenges. Key factors of its development are as follows: a significant reduction in the price for energy technology over time, an increase in the cost of traditional energy sources, raising level of environmental standards, state support for energy efficiency projects.

3. The structure of the United States energy balance is characterized by the dominance of traditional energy sources: gas and oil (45% of shale oil), the production and consumption of which continues to grow. Against the background of falling prices for these primary resources, there is also a sharp decline in the coal industry and an increasing role of renewable energy sources, as evidenced by a significant share in total electricity production (15%). Now the United States is acquiring more and more features of a self-sufficient country in terms of energy, having received the status of a net exporter of gas in 2016 and the leader in sales of refined petroleum products. The level of energy supply of the country is in the focus of the government policy, which is confirmed by a number of relevant legislative projects that set energy saving standards and provide for the encouragement of alternative energetics development; as well as relevant programs of the Presidential Administration. However, the coal industry can get a second chance due to the new emphasis of state policy according to «The First Energy Plan of America» which also implies the intensive use of domestic reserves of oil and gas.

4. By the level of energy security, the United States occupies a leading position, which has improved in recent years, in the global ranking. However, the energy security index of the United States is characterized by a downward trend. The determining factors of this phenomenon are significant amounts of energy resources imports, high level of energy resources consumption and imperfection of the method of calculation of the energy security index. The main drawbacks of the method of determining the level of energy security should be considered the following ones: failure to consider the level of alternative energetics

sector development, as well as the fact that significant amounts of imported energy resources undergoing processing are transformed into petroleum products exports. And therefore we consider appropriate to adjust the methodology of determining the level of energy security by incorporating indicators characterizing the level of development of alternative energetics (volumes of introduction of renewable energy sources, investment in the development of renewable energy sources) in the calculations, and replacement of the energy resources import volume index for the volumes of consumed imported energy. In the future, the state of energy security will have a stable moderate tendency to improve under the influence of close relations with a number of factors that are in stable upward trends (development of alternative energetics, energy resources exports, appreciation of the national currency, global competitiveness), which has been confirmed by the authors' calculations.

5. Throughout the United States, there are opportunities for the development of alternative energetics, especially geothermal, in particular the western regions have significant potential for realization of projects for the extraction of wind, water and solar energy. In addition, experts predict that the government creating favorable conditions for alternative energetics development projects and support from local authorities will allow the United States to almost completely switch to renewable energy sources by 2050.

Therefore, under conditions of limited resources, the implementation of an effective energy policy which implies support for the development of alternative energetics will allow the United States not only to preserve energy independence but also to increase the level of energy security and to hold leadership positions.

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ANEXES

Annex 1

Calculation Of Intermediate Parameters To Establish Correlation Between Energy Security Of The United States And Consumption Of Alternative Energy

Year	*Y*	*X*	$y_i - \bar{y}$	$x_i - \ddot{x}$	$(x_i - \ddot{x}) \cdot (y_i - \bar{y})$	$(y_i - \bar{y})$I	$(x_i - \ddot{x})$I
2006	95,90	6,27	5,95455	-0,87727	-5,2237603	35,45661	0,769607
2007	95,5	6,05	5,554545	-1,09727	-6,0948512	30,85298	1,204007
2008	98,7	6,72	8,754545	-0,42727	-3,7405785	76,64207	0,182562
2009	89,2	6,5	-0,74545	-0,64727	0,4825124	0,555702	0,418962
2010	96,6	6,72	6,654545	-0,42727	-2,8433058	44,28298	0,182562
2011	101	7,49	11,05455	0,342727	3,7886942	122,203	0,117462
2012	91,4	7,17	1,454545	0,022727	0,0330579	2,115702	0,000517
2013	87,2	7,7	-2,74545	0,552727	-1,5174876	7,537521	0,305507
2014	80,7	8	-9,24545	0,852727	-7,8838512	85,47843	0,727144
2015	77,2	7,7	-12,7455	0,552727	-7,0447603	162,4466	0,305507
2016	76	8,3	-13,9455	1,152727	-16,075305	194,4757	1,32878
∑	989,4	78,62	-5,7E-14	-1,8E-15	-46,119636	762,0473	5,542618
φ	89,94545	7,147273	-5,2E-15	-1,6E-16	-4,1926942	69,27702	0,503874

$$r_{xy} = \frac{\sum (x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \times \sum (y_i - \bar{y})^2}} = -0{,}70964$$

Y – energy security index of the United States
X – consumption of alternative energy, sq. BTU per year

Pearson correlation coefficient = – 0.70964
Source: authors' calculations

Annex 2

Calculation Of Intermediate Parameters To Establish Correlation Between Energy Security Of The United States And Energy Resources Export

Year	*Y*	*X*	$y_i - \bar{y}$	$x_i - \ddot{x}$	$(x_i - \ddot{x}) \cdot (y_i - \bar{y})$	$(y_i - \bar{y})$I	$(x_i - \ddot{x})$I
2006	95,90	4,58	5,95455	-4,82727	-28,74421488	35,45661	23,30256
2007	95,5	5,17	5,554545	-4,23727	-23,53612397	30,85298	17,95448
2008	98,7	6,86	8,754545	-2,54727	-22,30021488	76,64207	6,488598
2009	89,2	6,77	-0,74545	-2,63727	1,965966942	0,555702	6,955207
2010	96,6	8,11	6,654545	-1,29727	-8,632760331	44,28298	1,682917
2011	101	10,35	11,05455	0,942727	10,42142149	122,203	0,888735
2012	91,4	11,2	1,454545	1,792727	2,607603306	2,115702	3,213871
2013	87,2	11,7	-2,74545	2,292727	-6,294578512	7,537521	5,256598
2014	80,7	12,2	-9,24545	2,792727	-25,82003306	85,47843	7,799326
2015	77,2	12,8	-12,7455	3,392727	-43,24185124	162,4466	11,5106
2016	76	13,74	-13,9455	4,332727	-60,42185124	194,4757	18,77253
∑	989,4	103,48	-5,7E-14	7,11E-15	-203,9966364	762,0473	103,8254
φ	89,94545	9,407273	-5,2E-15	6,46E-16	-18,54514876	69,27702	9,438674

$$r_{xy} - \frac{\sum(x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum(x_i \quad \bar{x})^2 \times \sum(y_i \quad \bar{y})^2}} - -0{,}72521$$

Y – energy security index of the United States
X – energy resources export of the United States, sq. BTU per year

Pearson correlation coefficient = – 0.72524
Source: authors' calculations

Annex 3

Calculation Of Intermediate Parameters To Establish Correlation Between Energy Resources Export And Consumption Of Alternative Energy Of The United States

Year	*Y*	*X*	$y_i - \bar{y}$	$x_i - \ddot{x}$	$(x_i - \ddot{x}) \cdot (y_i - \bar{y})$	$(y_i - \bar{y})$I	$(x_i - \ddot{x})$I
2006	4,58	6,27	-4,82727	-0,87727	4,234834711	23,30256	0,769607
2007	5,17	6,05	-4,23727	-1,09727	4,649443802	17,95448	1,204007
2008	6,86	6,72	-2,54727	-0,42727	1,088380165	6,488598	0,182562
2009	6,77	6,5	-2,63727	-0,64727	1,707034711	6,955207	0,418962
2010	8,11	6,72	-1,29727	-0,42727	0,554289256	1,682917	0,182562
2011	10,35	7,49	0,942727	0,342727	0,323098347	0,888735	0,117462
2012	11,2	7,17	1,792727	0,022727	0,040743802	3,213871	0,000517
2013	11,7	7,7	2,292727	0,552727	1,267252893	5,256598	0,305507
2014	12,2	8	2,792727	0,852727	2,381434711	7,799326	0,727144
2015	12,8	7,7	3,392727	0,552727	1,875252893	11,5106	0,305507
2016	13,74	8,3	4,332727	1,152727	4,994452893	18,77253	1,32878
∑	103,48	78,62	7,11E-15	-1,8E-15	23,11621818	103,8254	5,542618
φ	9,407273	7,147273	6,46E-16	-1,6E-16	2,10147438	9,438674	0,503874

$$r_{xy} = \frac{\sum(x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \times \sum(y_i - \bar{y})^2}} = 0{,}96362$$

Y – energy resources export, sq. BTU per year
X – consumption of alternative energy, sq. BTU per year

Pearson correlation coefficient = 0.96362
Source: authors' calculations

Annex 4

Calculation Of Intermediate Parameters To Establish Correlation Between Energy Security Of The United States And Energy Intensity Of GDP

Year	*Y*	*X*	$y_i - \bar{y}$	$x_i - \ddot{x}$	$(x_i - \ddot{x}) \cdot (y_i - \bar{y})$	$(y_i - \bar{y})$I	$(x_i - \ddot{x})$I
2006	95,9	0,177	5,954545	0,018636	0,110971074	35,45661	0,000347
2007	95,5	0,171	5,554545	0,012636	0,070189256	30,85298	0,00016
2008	98,7	0,167	8,754545	0,008636	0,075607438	76,64207	7,46E-05
2009	89,2	0,163	-0,74545	0,004636	-0,003456198	0,555702	2,15E-05
2010	96,6	0,163	6,654545	0,004636	0,030852893	44,28298	2,15E-05
2011	101	0,159	11,05455	0,000636	0,007034711	122,203	4,05E-07
2012	91,4	0,153	1,454545	-0,00536	-0,007801653	2,115702	2,88E-05
2013	87,2	0,151	-2,74545	-0,00736	0,020216529	7,537521	5,42E-05
2014	80,7	0,15	-9,24545	-0,00836	0,07732562	85,47843	7E-05
2015	77,2	0,145	-12,7455	-0,01336	0,17032562	162,4466	0,000179
2016	76	0,143	-13,9455	-0,01536	0,214252893	194,4757	0,000236
∑	989,4	1,742	-5,7E-14	-1,1E-16	0,765518182	762,0473	0,001193
φ	89,94545	0,158364	-5,2E-15	-1E-17	0,069592562	69,27702	0,000108

Y – energy security index of the United States
X – energy intensity of GDP, koe/$2005

$$r_{xy} = \frac{\sum(x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \times \sum(y_i - \bar{y})^2}} = 0{,}80302$$

Pearson correlation coefficient = 0.80302
Source: authors' calculations

Annex 5

Calculation Of Intermediate Parameters To Establish Correlation Between Energy Intensity Of GDP And Consumption Of Alternative Energy

Year	*Y*	*X*	$y_i - \bar{y}$	$x_i - \ddot{x}$	$(x_i - \ddot{x}) \cdot (y_i - \bar{y})$	$(y_i - \bar{y})$I	$(x_i - \ddot{x})$I
2006	0,177	6,27	0,018636	-0,87727	-0,016349174	0,000347	0,769607
2007	0,171	6,05	0,012636	-1,09727	-0,013865537	0,00016	1,204007
2008	0,167	6,72	0,008636	-0,42727	-0,003690083	7,46E-05	0,182562
2009	0,163	6,5	0,004636	-0,64727	-0,003000992	2,15E-05	0,418962
2010	0,163	6,72	0,004636	-0,42727	-0,001980992	2,15E-05	0,182562
2011	0,159	7,49	0,000636	0,342727	0,000218099	4,05E-07	0,117462
2012	0,153	7,17	-0,00536	0,022727	-0,000121901	2,88E-05	0,000517
2013	0,151	7,7	-0,00736	0,552727	-0,004070083	5,42E-05	0,305507
2014	0,15	8	-0,00836	0,852727	-0,007131901	7E-05	0,727144
2015	0,145	7,7	-0,01336	0,552727	-0,007386446	0,000179	0,305507
2016	0,143	8,3	-0,01536	1,152727	-0,017710083	0,000236	1,32878
∑	1,742	78,62	-1,1E-16	-1,8E-15	-0,075089091	0,001193	5,542618
φ	0,158364	7,147273	-1E-17	-1,6E-16	-0,006826281	0,000108	0,503874

$$r_{xy} = \frac{\sum (x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \times \sum (y_i - \bar{y})^2}} = -0{,}9236$$

Y – energy intensity of GDP, koe/$2005
X – consumption of alternative energy, sq. BTU per year
Pearson correlation coefficient = -0.9236
Source: authors' calculations

Annex 6

Initial Data For Calculation Of The Energy Security Elasticity Coefficient When Changing The Index Of Energy Intensity Of Gdp

	The energy security index of the United States	Index of the energy intensity of GDP, koe/$2005
2006	95,9	0,177
2007	95,5	0,171
2008	98,7	0,167
2009	89,2	0,163
2010	96,6	0,163
2011	101	0,159
2012	91,4	0,153
2013	87,2	0,151
2014	80,7	0,15
2015	77,2	0,145
2016	76	0,143
average value	89,94545455	0,158363636

$$\bar{Э} = f'(x) * \frac{\bar{x}}{\bar{y}}$$

Y – energy security index of the United States
X – energy intensity of GDP, koe/$2005
Regression equation: y=-11.7113+641.9195x

Elasticity coefficient = 1.13
Source: authors' calculations

Annex 7

Initial Data For Calculation Of The Elasticity Coefficient Of Energy Security To A Number Of Factors

	The energy security index of the United States	The consumption of alternative energy, sq. BTU per year
2006	95,9	6,27
2007	95,5	6,05
2008	98,7	6,72
2009	89,2	6,5
2010	96,6	6,72
2011	101	7,49
2012	91,4	7,17
2013	87,2	7,7
2014	80,7	8
2015	77,2	7,7
2016	76	8,3
average value	89,94545455	7,147272727

Y – energy security index of the United States
X – consumption of alternative energy, sq. BTU per year
Regression equation: y=149.4173-8.32091x
Elasticity coefficient:

$$\overline{Э} = f'(x) * \frac{\overline{x}}{\overline{y}}$$

Elasticity coefficient = -0.66

	The energy security index of the United States	The energy resources export, sq. BTU per year
2006	95,9	4,58
2007	95,5	5,17
2008	98,7	6,86
2009	89,2	6,77
2010	96,6	8,11
2011	101	10,35
2012	91,4	11,2
2013	87,2	11,7
2014	80,7	12,2
2015	77,2	12,8
2016	76	13,74
average value	89,94545455	9,407272727

Y – energy security index of the United States
X – energy resources export, sq. BTU per year
Regression equation: y=108.4289-1.9648x
Elasticity coefficient:

$$\overline{Э} = f'(x) * \frac{\overline{x}}{\overline{y}}$$

Elasticity coefficient = -0.21

	The energy security index of the United States	The exchange rate of the United States dollar against the euro
2006	95,9	0,76
2007	95,5	0,68
2008	98,7	0,72
2009	89,2	0,7
2010	96,6	0,75
2011	101	0,77
2012	91,4	0,76
2013	87,2	0,72
2014	80,7	0,82
2015	77,2	0,91
2016	76	0,95
average value	89,94545455	0,776363636

Y – energy security index of the United States
X – exchange rate of the United States dollar against the euro
Regression equation: y=150.984-78.6211x
Elasticity coefficient:

$$\overline{Э} = f'(x) * \frac{\overline{x}}{\overline{y}}$$

Elasticity coefficient = -0.68

	The energy security index of the United States	The index of global competitiveness
2006	95,9	5,61
2007	95,5	5,67
2008	98,7	5,74
2009	89,2	5,59
2010	96,6	5,43
2011	101	5,43
2012	91,4	5,47
2013	87,2	5,48
2014	80,7	5,54
2015	77,2	5,61
2016	76	5,7
average value	89,94545455	5,57

Y – energy security index of the United States
X – index of global competitiveness
Regression equation: y=192.0621-18.3333x
Elasticity coefficient:

$$\overline{Э} = f'(x) * \frac{\overline{x}}{\overline{y}}$$

Elasticity coefficient = -0.21

Source: authors' calculations