Research paper / Оригинальная статья
https://doi.org/10.51176/1997-9967-2023-2-135-147
МРНТИ: 06.52.13
JEL: O13, O25, Q32

Check for updates
BY-NC 4.0

The Impact of Energy Transition Risks on the Sustainable Development of Kazakhstan's Economy

Bibigul S. Saubetova[a]*, Gaukhar A. Saimagambetova[a], Aigul I. Esturlieva[a], Gulimay D. Amaniyazova[a]

[a] *Caspian university of technologies and engineering named after S.Yessenov, 32 microdistrict, R00H6B2, Aktau, Kazakhstan*

For citation: Saubetova, B. S., Saimagambetova, G. A., Esturlieva, A. I. & Amaniyazova, G. D. (2023). The Impact of Energy Transition Risks on the Sustainable Development of Kazakhstan's Economy. Economics: the Strategy and Practice, 18(2), 135-147, https://doi.org/10.51176/1997-9967-2023-2-135-147

ABSTRACT

The purpose of the study is to determine the prospects and difficulties of Kazakhstan's energy transition, as well as to analyze the direction of development of the electric power sector to overcome the difficulties that have developed today. The global trends of transition to a carbon-free economy, the foundation for which was laid during the crisis of 2008, are currently being strengthened under the influence of two factors. Firstly, the fact of climate change as a result of anthropogenic impact is recognized by the world community. Secondly, the economic crisis caused by the COVID-19 pandemic has pushed many states, investors, as well as private companies to more actively implement decarbonization strategies. This is not only due to concern about increasing environmental problems. Decarbonization and energy transition can become an effective tool for stimulating economic development through the development of technology, attracting investment and creating new jobs. The analysis of the consequences of the considered trend for Kazakhstan is carried out. It is shown that the country's strategic documents reflect a cautious approach based on plans to increase hydrocarbon exports. However, we believe that maintaining this approach is fraught with a number of economic and political risks. According to the results of the study, the importance of developing comprehensive strategic approaches aimed at leveling the identified risks is emphasized, and specific proposals for the implementation of a gradual energy transition in Kazakhstan are formulated.

KEYWORDS: Energy Transition, Sustainable Development, Strategic Approaches, Crisis, Risks, Financing and Subsidizing of Energy

CONFLICT OF INTEREST: the authors declare that there is no conflict of interest.

FINANCIAL SUPPORT: the study was not sponsored (own resources).

Article history:
Received 07 April 2023
Accepted 16 May 2023
Published 30 June 2023

*** Corresponding author: Saubetova B.S.** – Cand. Sc. (Econ.), Caspian university of technologies and engineering named after S. Yessenov, 32 microdistrict, R00H6B2, Aktau, Kazakhstan, 87020750010, email: bs.saubetova@mail.ru

Энергетикалық көшу тәуекелдерінің Қазақстан экономикасының тұрақты дамуына әсері

Саубетова Б.С.[a]*, Саймагамбетова Г.А.[a], Естурлиева А.И.[a], Аманиязова Г.Д.[a]

[a] Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Микроаудан 32, R00H6B2, Ақтау, Қазақстан

Дәйексөз үшін: Саубетова Б.С., Саймагамбетова Г.А., Естурлиева А.И., Аманиязова Г.Д. (2023). Энергетикалық көшу тәуекелдерінің Қазақстан экономикасының тұрақты дамуына әсері. Экономика: стратегия және практика, 18(2), 135-147, https://doi.org/10.51176/1997-9967-2023-2-135-147

ТҮЙІН

Зерттеудің мақсаты Қазақстанның энергетикалық ауысуының келешегі мен күрделілігін айқындау, сондай-ақ бүгінгі таңда қалыптасқан қиындықтарды еңсеру үшін электр энергетикасы секторының даму бағытын талдау болып табылады. 2008 жылғы дағдарыс кезеңінде негізі қаланған көміртексіз экономикаға көшудің әлемдік тенденциялары Қазіргі уақытта екі фактордың әсерінен күшейіп келеді. Біріншіден, әлемдік қауымдастық антропогендік әсердің нәтижесі ретінде климаттың өзгеру фактісін мойындады. Екіншіден, COVID-19 пандемиясынан туындаған экономикалық дағдарыс көптеген мемлекеттерді, инвесторларды, сондай-ақ жеке компанияларды декарбонизация стратегияларын белсенді түрде жүзеге асыруға итермеледі. Бұл өсіп келе жатқан экологиялық мәселелермен ғана байланысты емес. Декарбонизация және энергетикалық ауысу технологияларды дамыту, инвестицияларды тарту және жаңа жұмыс орындарын құру арқылы экономиканың дамуын ынталандырудың тиімді құралы бола алады. Қаралған трендтің Қазақстан үшін салдарына талдау жүргізілді. Елдің стратегиялық құжаттарында көмірсутектер экспортын ұлғайту жоспарларына негізделген сақтықпен қарау тәсілі көрініс тапқаны көрсетілген. Алайда, біз бұл тәсілді сақтау бірқатар экономикалық және саяси тәуекелдерге толы деп санаймыз. Жүргізілген зерттеу нәтижелері бойынша белгіленген тәуекелдерді нивелирлеуге бағытталған кешенді стратегиялық тәсілдерді әзірлеудің маңыздылығы атап көрсетіліп, Қазақстанның біртіндеп энергетикалық ауысуын іске асыру бойынша нақты ұсыныстар тұжырымдалды.

ТҮЙІН СӨЗДЕР: энергетикалық ауысу, тұрақты даму, стратегиялық тәсілдер, дағдарыс, тәуекелдер, энергетиканы қаржыландыру және субсидиялау

МҮДДЕЛЕР ҚАҚТЫҒЫСЫ: авторлар мүдделер қақтығысының жоқтығын мәлімдейді.

ҚАРЖЫЛАНДЫРУ: зерттеуге демеушілік қолдау көрсетілмеді (меншікті ресурстар).

Мақала тарихы:
Редакцияға түсті 07 Сәуір 2023
Жариялау туралы шешім қабылданды 16 Мамыр 2023
Жарияланды 30 Маусым 2023

*** Хат-хабаршы авторы: Саубетова Г.А. –** э.ғ.к., Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Микроаудан 32, R00H6B2, Ақтау, Қазақстан, 87020750010, email: bs.saubetova@mail.ru

Влияние рисков энергетического перехода на устойчивое развитие экономики Казахстана

Саубетова Б.С.[a]*, Саймагамбетова Г.А.[a], Естурлиева А.И.[a], Аманиязова Г.Д.[a]

[a] *Каспийский университет технологий и инжиниринга им.Ш.Есенова, микрорайон 32, R00H6B2, Актау, Казахстан*

Для цитирования: Саубетова Б.С., Саймагамбетова Г.А., Естурлиева А.И., Аманиязова Г.Д. (2023). Влияние рисков энергетического перехода на устойчивое развитие экономики Казахстана. Экономика: стратегия и практика, 18(2), 135-147, https://doi.org/10.51176/1997-9967-2023-2-135-147

АННОТАЦИЯ

Целью исследования является определение перспектив и сложностей энергетического перехода Казахстана, а также анализ направления развития сектора электроэнергетики для преодоления сложностей, сложившихся на сегодняшний день. Мировые тенденции перехода к безуглеродной экономике, основа для которой была заложена в период кризиса 2008 г., в настоящее время усиливаются под влиянием двух факторов. Во-первых, мировым сообществом признан факт изменения климата как результата антропогенного воздействия. Во-вторых, экономический кризис, вызванный пандемией COVID-19, подтолкнул многие государства, инвесторов, а также частные компании к более активной реализации стратегий декарбонизации. Это объясняется не только озабоченностью усиливающимися экологическими проблемами. Декарбонизация и энергетический переход могут стать эффективным инструментом для стимулирования развития экономики за счет развития технологий, привлечения инвестиций и создания новых рабочих мест. Проведен анализ последствий рассмотренного тренда для Казахстана. Показано, что в стратегических документах страны нашел отражение осторожный подход, основанный на планах наращивания экспорта углеводородов. Однако мы считаем, что сохранение данного подхода чревато рядом экономических и политических рисков. По результатам проведенного исследования подчеркивается важность выработки комплексных стратегических подходов, направленных на нивелирование обозначенных рисков, сформулированы конкретные предложения по реализации постепенного энергетического перехода Казахстана.

КЛЮЧЕВЫЕ СЛОВА: энергетический переход, устойчивое развитие, стратегические подходы, кризис, риски, финансирование и субсидирование энергетики

КОНФЛИКТ ИНТЕРЕСОВ: авторы заявляют об отсутствии конфликта интересов.

ФИНАНСИРОВАНИЕ: исследование не имело спонсорской поддержки (собственные ресурсы).

История статьи:
Получено 07 апреля 2023
Принято 16 мая 2023
Опубликовано 30 июня 2023

*** Корреспондирующий автор: Саубетова Г.А. –** к.э.н., Каспийский университет технологий и инжиниринга им.Ш.Есенова, Микроаудан 32, R00H6B2, Актау, Казахстан, 87020750010, email: bs.saubetova@mail.ru

Introduction

Switching to alternative energy sources that produce less carbon dioxide is an ongoing task known as energy transition (Lyu et al., 2022; Hordeski, 2020). More than 70% of all emissions in the world are from the energy industry, including emissions from using energy for heating, transport and production (Reuters, 2019). Throughout history, there has been a correlation between the ever-increasing need for power and the availability of alternative forms of energy. The current transition to renewable energy differs from previous ones because it is primarily driven by the realization that greenhouse gas emissions must be reduced to zero globally.

The energy system offers sustainable opportunities for the world to maintain a balanced, healthy ecology and human life. As a result, an energy transition is taking place all over the planet (Specht & Madlener, 2019). Energy transformations are associated with a deliberate and paradigmatic shift from an outdated energy production infrastructure and a strong consumption dependence on high-carbon non-renewable energy sources to a more efficient low-carbon energy balance. The energy transition also represents a global attempt to decarbonize the energy system in order to reduce its carbon footprint from the energy industry and minimize the effects of climate change (Worighi et al., 2019). Thus, this transition method involves introducing renewable energy technologies into the energy sector to replace existing energy technologies based on fossil fuels. It also includes measures to save energy and improve energy efficiency (Kodaneva, 2022).

2020 was marked not only by the COVID-19 pandemic, it also ended the warmest 10-year period. It became the second warmest year in the history of meteorological observations (2020 Ends earth's warmest ten years on record, 2021). Greenhouse gases in the atmosphere have reached the highest concentrations for the entire observation period. These changes have an increasingly negative impact not only on natural systems but also on humans and technology: for example, 75% of new infectious diseases, such as Ebola, SARS, NIPAH, avian influenza and COVID-19, are of zoonotic origin; an increase in temperature leads to natural anomalies that entail such negative socio-economic consequences as a decrease in income, especially for those groups of the population who live in rural areas, forced migration, etc. Climate change and extreme weather events have a negative impact on the security of energy supply (Zheng, 2021).

Awareness of the ever-increasing risks (economic, social and environmental) associated with the effects of climate change has pushed the governments of many countries around the world to adopt various variations of the green course, decarbonization of the economy and energy transition. The COVID-19 pandemic has reinforced these trends. Furthermore, although the lockdown and the fall in oil and gas prices for some time reduced the relevance of the energy transition issue and even called it into question, experts note that this is a short-term trend. Thus, most governments and large investment funds of developed countries are calling for green projects to be invested in the framework of combating the consequences of the coronacrisis.

Decarbonization and low–carbon development is the primary long-term trend in the development of global energy. Thus, as of September 2021, as part of the implementation of the 2015 Paris Agreement, more than 100 countries have committed themselves to achieve carbon neutrality by 2050, including the EU, USA, Great Britain, Bhutan, Costa Rica, Fiji, Japan, China, South and North Korea, Uruguay, etc. (Henderson & Sen, 2021).

Long-term changes, or energy transitions, are primarily associated with socio-economic development and technological innovations. In the past, they occurred organically, reflecting innovation cycles. Today, this pattern is supplemented by the globally recognized fact of climate change's anthropogenic cause and its numerous negative consequences. Accordingly, this introduces a new driving force that stimulates energy transition – its conditionality by state policy implemented in higher standards and various measures to support and stimulate investment.

Research Materials and Methods

The research examined publicly available statistical information about the global energy market and the energy market of Kazakhstan. The report includes an evaluation of the significance of coal in Kazakhstan's energy mix, examining the progress made in renewable energy development, and assessing the current operational and commissioned facility capacities.

A comprehensive analysis has been carried out, which provides both quantitative and qualitative characteristics of the development and impact of the energy transition on the sustainable development of the economy of Kazakhstan. The main research methods were: analytical and synthetic, statistical, computational and analytical research methods. The graphical representation of the generalized data made it possible to reflect the dynamics of the development of this industry. A map of the energy intensity of the world's economies is presented.

The analytical method allowed to form a comprehensive vision of the current state of the world energy market and the energy market of Kazakhstan. Based on the applied methodology, a scientific justification of the current stage of the energy transition and its impact on the socio-economic development of Kazakhstan was given.

The tasks set in the article were solved by analyzing the structure, dynamics, and financial analysis methods. This study used the GM dynamic panel for regression analysis, and FMOLS and DOLLS were used as reliability models. Data sets on sustainable development, environmental sustainability and energy transition of OECD countries were used. The period covered by the study was from 2000 to 2020.

Results and Discussion

As a result of the rapid spread of renewable energy sources, more and more studies are being conducted in many countries to study the impact of the use of renewable energy sources on environmental quality, as well as on economic growth on a national, regional and global scale (Lyu et al., 2022; Kumaran et al., 2020). The results of these studies confirm the existence of an ecological Kuznets curve between CO2 emissions, confirming the hypothesis that using renewable energy sources reduces carbon dioxide emissions (Razmjoo et al., 2021).

On the contrary, the use of non-renewable energy sources increases CO2 emissions. Other studies have focused on the relationship between the amount of energy consumed by a country and the pace of its economic growth (Baloch et al., 2020). It studied how energy consumption, economic growth and environmental emissions are related. The results of these studies varied greatly depending on the nation studied; this discrepancy is due to several elements unique to each of these empirical studies (Abbas & Chaudhry, 2017).

In contrast to the previously discussed common analytical approaches, the most recent empirical studies investigate the relationship between economic growth and the transition to renewable energy sources (Abbas et al., 2020; Shen et al., 2021). Many researchers have focused on how economic growth can facilitate the transition to new energy sources while mitigating the effects of global warming (Wu et al., 2021). In recent years, there has been a growing number of studies in the field of economics that study how the developing economy affects the consumption of both renewable and non-renewable forms of energy (Wei et al., 2021; Chaudhry et al., 2021). In addition, it is becoming increasingly common practice in the field of environmental policy, energy policy and innovation policy to study the structure of complex policies. This is a popular approach in the field of policy research and practice (Hao et al., 2021).

There are various definitions of energy transition in modern scientific literature. However, almost all of them boil down to the fact that energy transition means abandoning hydrocarbons in favor of green energy as an effective way to reduce carbon emissions and achieve low-carbon development.

However, one cannot agree with such a narrow vision of this phenomenon. The energy transition is not only about green energy. "First of all, it is the organization of the transition of the world's leading economies to a new technological order" (From the report of Belousov A.R., 2021). Innovative solutions are also being developed in such areas as energy intensity reduction, transmission, conversion and storage of energy, management of large power systems and hydrogen energy. Accordingly, new technological solutions in the energy field are deeply integrated with modern information, communication and digital technologies that make it possible to create an intelligent energy system.

Thus, the energy transition should be understood as a technological transformation, including gradual changes, such as energy efficiency improvements, structural transformations caused by the abandonment of some fuels in favor of others and systemic shifts, such as the abandonment of fossil fuels in favor of the electric power industry, the large-scale use of digital and intelligent technologies (smart grids, BIM, etc.) and the transition to hydrogen fuel.

The current level of technology development allows us to state that the energy transition is underway. However, there is still uncertainty both in terms of its timing and scenarios implemented in different regions of the world and the consequences for existing and future players in the energy market. At the same time, prices for key technologies in the field of renewable energy are constantly decreasing, and their availability to consumers is increasing. For example, solar photovoltaic modules (PV) have decreased by about 90% over the past decade (Roser, 2020), and wind turbines – by 55-60%.

As per the International Energy Agency (IEA), renewable energy sources are projected to contribute 90% of new capacity growth globally shortly. This is because constructing new wind or solar facilities is currently more cost-effective than continuing to operate 60% of existing coal-based power plants (Tracker, 2020). In May 2021, the IEA released a special report titled Net Zero by 2050. A Roadmap for the Global Energy Sector, which states that "there is no requirement to invest in fresh supplies of fossil fuels. Besides the projects already sanctioned for 2021, our roadmap does not necessitate developing new coal mines, oil and gas fields, or extending the existing ones" (Marshall, 2021).

In analyzing this report, paying attention to several important points is necessary. Firstly, the pace, scale and scenarios of the energy transition may vary significantly in different regions, up to the preservation of directly opposite trends in Africa and several Asian countries, due to both different levels of socio-economic development and established energy models. This is clearly seen in the example of the use of coal and nuclear energy in Europe, where opinions about the future of both energy sources vary greatly. The starting point for the energy transition also differs in the world as a whole.

The European Union continues to implement its decarbonization plans by raising the prices of emissions in the EU ETS, which in turn affects the final prices for fuel and electricity. What is the main challenge for our country, so that, like the European Union, Kazakhstan can continue the decarbonization agenda to benefit society and the future generation? Is our country ready to liberalize the electricity market? Are we ready to give an opportunity and guarantees to investors seeking to invest in developing renewable energy infrastructure and intelligent technologies of electricity transmission networks?

The energy transition is a complex but possible transformation that requires significant investments and, most importantly, conditions and a coordinated, systematic approach between all participants, where the state plays a decisive role. For the development of the industry, a vector of development is needed so that plans can be made. Therefore, the most critical step is to develop a comprehensive strategy that will define a long-term vision for developing the country's energy sector.

Kazakhstan has one of the most energy-intensive economies in the world. According to the Enerdata agency, by the end of 2020, Kazakhstan entered the top ten most energy-intensive economies globally with an indicator of 0.149 koe/$15p. (a kilogram of oil equivalent for 15 US dollars). Such indicators indicate the low energy efficiency of production due to outdated equipment and inefficient processes. At the same time, the share of coal in the structure of Kazakhstan's final energy consumption is about 20%. Energy intensity of the economies of the world in 2020 presented in Figure 1.

According to IHS Markit, despite Kazakhstan's efforts to achieve carbon neutrality by 2060 through various programs such as the adoption of renewable energy sources, coal consumption remains dominant in the country's primary energy resources, accounting for over 50% in 2021 or approximately 92 million tons of oil equivalent. It is projected that coal will continue to have a significant presence in Kazakhstan's energy mix, particularly in electricity production, until 2040.

Kazakhstan's coal exports have faced significant logistical difficulties due to the conflict between Russia and Ukraine. Significant investments in fossil fuels lead to difficulties in developing green and alternative energy in Kazakhstan (1/2). Subsidies to the coal industry of Kazakhstan, according to the IEA, described in Figure 2.

The total estimate of financing and subsidizing coal-fired energy per year (2019-2021, UNDP) amounted to 100 billion tenge. Kazakhstan ranked 12th in the world in 2020 in terms of investments in fossil fuels. One hundred fifty billion tenge was invested in renewable energy in 2021, while 780 billion tenge has been invested in renewable energy since 2014.

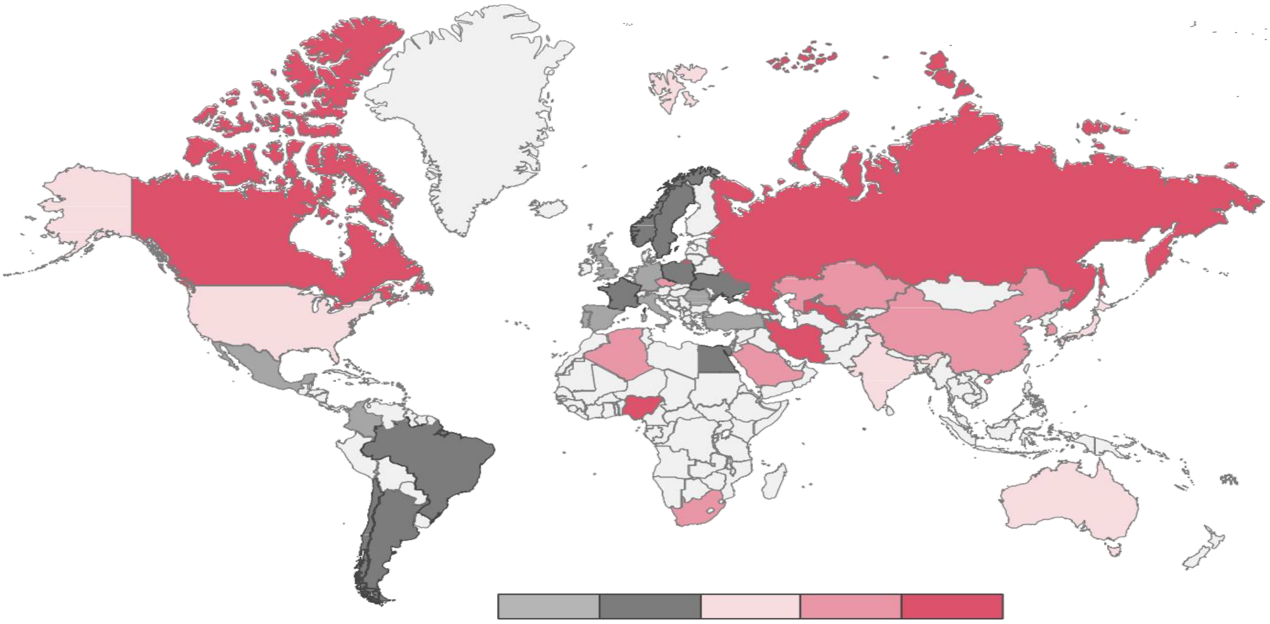

Figure 1 - Energy intensity of the economies of the world, 2020

Note: compiled by authors based on ENERDATA, IEA

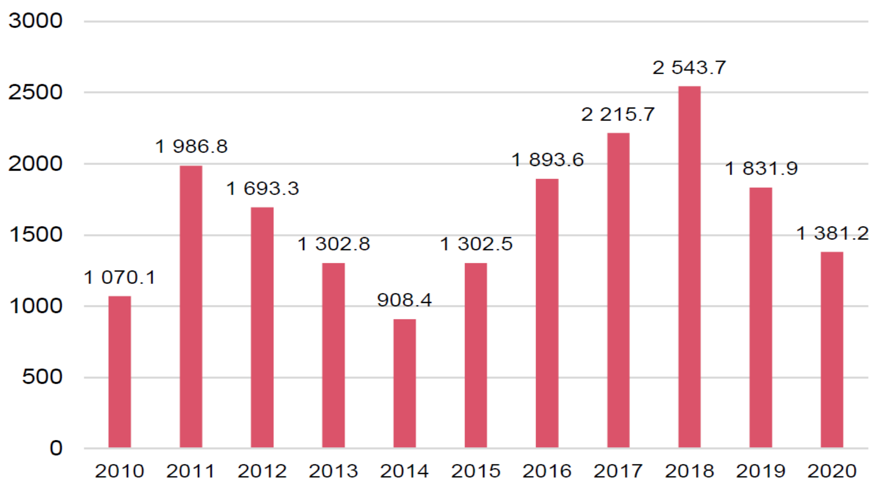

Figure 2 - Subsidies to the coal industry of Kazakhstan according to the IEA for 2010-2020, million US dollars

Note: compiled by authors

In Kazakhstan, subsidies are mainly made in the form of:

• direct subsidies to energy producers,

• direct financing of infrastructure projects in the energy sector,

• tax benefits for mining companies,

• price restraint on goods and services that form the leading share of the cost of coal.

According to world experience, subsidizing fossil fuel energy can hinder achieving low-carbon development goals. Subsidizing fossil fuels can lead to an increase in energy consumption, inhibit the development of renewable and alternative energy, and artificially lower tariffs. In addition, there is a critical question of the effectiveness of such a subsidy mechanism with a low level of implementation of various market-based methods for calculating tariffs.

The uncertainty surrounding global climate change makes it difficult to assess its impact on economic activity accurately. Climate shocks not only lead to severe economic losses but also affect the systemic indicators of financial stability. The climate crisis may lead to a decrease in the profitability of companies and the depreciation of specific categories of their assets, potentially leading to a deterioration in the ability of firms to service their debts and a higher level of defaults, negatively affecting financial stability. The risks affecting financial stability from climate change are usually divided into physical and transitional (Report, 2022).

Transitional risks associated with changes in policies aimed at mitigating the effects of climate change and adapting to a low-carbon economy affect market volatility and the value of financial assets and liabilities. The tightening of environmental regulation, through the adoption of the new Environmental Code No. 400-VI of January 2, 2021, the increase in the cost of quotas for greenhouse gas emissions in the Republic of Kazakhstan, as well as the introduction of a border carbon tax by the EU and other trading partners of the Republic of Kazakhstan, are the main factors of transition risks. These measures may negatively affect the profitability of the largest companies in critical sectors of the economy by reducing revenue, increasing capital and operating costs and increasing the cost of borrowed capital.

Together, these negative factors will lead to an increase in the debt burden of the corporate sector of the Republic of Kazakhstan. In addition, introducing carbon taxes will also lead to an increase in prices for essential fuel resources, leading to an increase in inflation.

The relationship between these risk categories and their magnitude will depend on whether the transition to a low-carbon economy is gradual or intensive. The lack of timely measures will lead to the materialization and intensification of physical risks in the foreseeable future. At the same time, excessive and spontaneous transition will reduce long-term physical risks but will increase short-term transition risks (Figure 3).

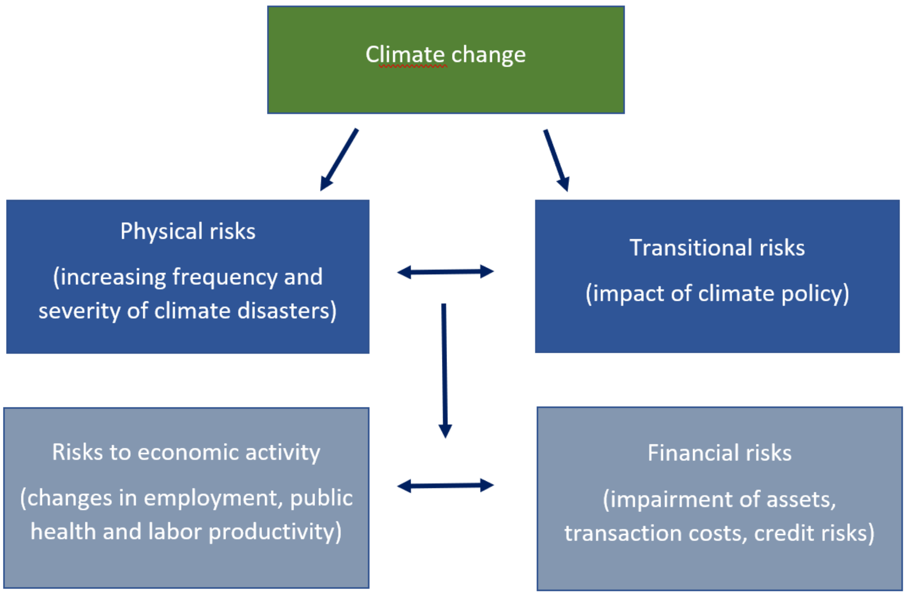

Figure 3 - Relationship between risks

Note: compiled by authors

According to the Global Carbon Atlas platform for 2020, Kazakhstan ranks 20th among 221 countries in terms of carbon dioxide emissions, 10th in terms of per capita emissions and 7th in terms of carbon intensity of GDP, where 80% of emissions come from operations related to the extraction and use of fossil fuels. Taking this into account, within the framework of the Paris Agreement, Kazakhstan has committed itself to reducing CO2 emissions by 15% by 2030 from 1990 values - from 386.3 million tons to 328.4 million tons of CO2 equivalent. The goal has been set to reduce the share of fossil energy resources in the structure of primary fuel and energy resources by 3.4 times to 29% by 2060 and increase the share of RES from 3% to 70%.

According to calculations by PwC Kazakhstan (2021), from 2013 to 2019, the cumulative average annual growth rate of commissioned renewable energy facilities in Kazakhstan is already 24%. Also, together with the World Bank, a roadmap for decarbonization from 2023 to 2030 was developed, covering seven economic sectors: industry, energy, utilities, agriculture, coal industry, transport and waste management (Marteau, 2021). Commitment to this policy will allow Kazakhstan to get closer to achieving its goal of ensuring carbon neutrality by 2060. The analysis of transitional risks is becoming one of the priority tasks of regulators around the world, and the central bank of Kazakhstan will also begin work on studying the impact of these risks on the economy of the Republic of Kazakhstan and developing strategies for taking into account climate risks.

Multicollinearity is a term used in regression modeling to refer to the relationship among forecasters, which can have an adverse impact on the regression outcomes. Detecting multicollinearity in a regression model is done by calculating a variance inflation factor (VIF) by formula (1):

$$VIF = \frac{1}{1 - R_i^2} \quad (1)$$

The dynamic effects of a model can be analyzed by including lagged dependent variables in the set of independent variables. Doing so adds an element of dynamism to the model, as the lagged dependent variables allow for the inclusion of historical information and its estimated impact on the independent variables. By contrast, excluding the lagged dependent variables results in a more pragmatic outcome, as the independent variables provide a complete picture of the situation. In other words, the lagged dependent variables represent the effect of the latest information on the model by formula (2):

$$C_{it} = \mu_i + \beta ESG_{it} + \rho C_{it} - 1 + \varepsilon_{it} \quad (2)$$

DOLS is a method that allows for the cointegration of diverse vectors under a given parameter. It is a parametric test that assumes normal distribution and helps to mitigate errors in static regressors by incorporating lead and lag values in the first differences. Alternatively, FMOLS is a nonparametric approach introduced by Pedroni in 2004. It corrects biases that arise in OLS due to endogeneity and serial correlation concerns among the vectors and residuals, making fewer assumptions. The DOLS approach is characterized by the equation presented below (3):

$$SDgap_t = \gamma_i + EM_i^{'}\beta + d_{1t}\psi_1 \sum \Delta EM_{t+j}^{'} \delta + \mu_{it} \quad (3)$$

In this case, FMOLS estimation can be performed with the following equation (4):

$$\omega_{GM} = N^{-1} \sum_{i=1}^{N} \left[\sum_{t=1}^{T} \left(\Delta EM_{it} - EM_i^{'} \right)^2 \right]^{-1} \left[\sum_{t=1}^{T} \left(EM_{it} - EM_i^{'} \right) SDgap_i^{'} - T\tau_i \right] \quad (4)$$

To begin the panel data analysis, the model's cross-sectional dependence is first examined, and the results are presented in Table 1. The analysis shows strong evidence that the panelists are subject to cross-sectional dependencies in their work. Such dependence in panel data can lead to biased results and lower estimator efficiency when using first-generation estimation methods. This is particularly true for nations that are important trading partners with numerous bilateral and multilateral arrangements and where energy imports are used in producing final products for international trade. Both null hypotheses of the tests indicate the presence of cross-sectional dependency at a significance level of one percent (Table 1).

After applying the dynamic panel GMM method carefully, we also used FMOLS and DOLS to confirm the robustness of the model mentioned earlier. The results of the robustness analysis are presented in Table 2.

Table 1 - Results of the cross-sectional dependency test

Variables	Breusch-pagan LM	Pesaran Scaled LM	Bias-Corrected Scaled LM	Pesaran CD
$GDP_{\_PC}$	4975.87***	118.09***	117.45***	20.02***
$EI_{\_GDP}$	17101.74***	450.34***	449.70***	129.84***
$TGDS_{\_R\&D}$	16396.43***	431.01***	430.37***	126.79***
$AGHG_{\_pc}$	17034.35***	448.49***	447.85***	129.86***
$E_{\_r}T$	6645.94***	163.85***	163.21***	42.91***
$TEC_{\_pc}$	6539.10***	160.92***	160.28***	30.92***
TREC	1643.60***	26.79***	26.15***	7.38***
TNREC	18582.83***	490.92***	490.28***	136.21***

**** shows the significance level at 1%.*

H_0: There is no cross-section dependency

H_1: There is the cross-section dependency

Note: compiled by authors

Table 2 - Results of robustness based on FMOLS and DOLS

	FMOLS Estimator			DOLS Estimator		
	TEC_pc	TREC	TNREC	TEC_pc	TREC	TNREC
$InGDP_{\_PC}$	0.353*** (0.042)	0.567*** (0.050)	-0.369*** (0.049)	0.735*** (0.051)	0.4752*** (0.049)	-0.1587*** (0.055)
InE_rT	0.954*** (0.058)	0.951*** (0.000)	-0.715*** (0.050)	0.314*** (0.000)	0.684*** (0.000)	-0.418*** (0.051)
$InEI_{\_GDP}$	0.205*** (0.051)	0.393*** (0.000)	-0.535*** (0.058)	0.571*** (0.044)	0.564*** (0.000)	-0.322*** (0.000)
$InTGDS_{\_R\&D}$	0.310*** (0.000)	0.415*** (0.049)	-0.201*** (0.000)	0.041*** (0.047)	0.904*** (0.000)	-0.188*** (0.051)
$InAGHG_{\_pc}$	0.344*** (0.000)	-0.136*** (0.049)	0.905*** (0.000)	0.792*** (0.035)	0.641*** (0.000)	0.721*** (0.024)

Note: compiled by authors

Conclusions

The analysis shows that the energy transition today is no longer a purely European trend but is becoming global. The support of the climate agenda by major international players – the United States, the EU and China – can contribute to the formation of stricter and more effective international regulation of CO2 emissions. This requires the rest of the world to take urgent measures to adapt to changing conditions, which is clearly demonstrated by a number of States in the Middle East and North Africa.

New global challenges will adjust the pace and plans for the energy transition in many countries. However, these challenges may bring new opportunities – countries and corporations will try to move away from high dependence on Russia in value chains, which may push them to reorient to new energy-efficient solutions and clean energy sources. All this will undoubtedly require large investments, which, due to rising inflation, will not bring the previously expected significant increase in capacity. The increase in the rate of inflation, in turn, is associated with rising prices for hydrocarbons, disruption of supply chains, and rising prices for electricity and fuel.

Empirical results have shown that sustainable development and a sustainable environment have a positive impact on the process of energy transition in OECD countries. However, these factors also negatively affect the consumption of non-renewable energy in OECD countries. This study used the GMM dynamic panel as the primary evaluator, while FMOLS and DOLS were used to determine the reliability of the study results. The results of this empirical study indicate that all independent variables (gross domestic product, openness to trade, gross domestic expenditure on research and development and environmental-related technologies), with the exception of atmospheric emissions and greenhouse gases, have a positive impact on total energy consumption and total renewable energy consumption, while how the total non-energy consumption is negatively related to these variables.

According to the results of our research, the OECD economies receive favorable assistance from sustainable economic development and environmentally sustainable conditions for a successful transition to a new energy source. These results show that decision-makers should design and develop effective support policies to attract investment in innovative renewable energy technologies. One of the policy solutions that can be implemented is to promote the development of renewable energy technology in achieving the comprehensive goal of transition to a sustainable energy system.

The fundamental program of routes for the development of various non-fossil fuel activities is to achieve a political goal, which is further specified in a set of political goals and tools when they cover this political strategy. To implement a new type of creation of favorable conditions, administrative reform will be required at both the global and international levels of government. It is crucial to ensure consistency in the management of high-quality strategies for sustainable and sustainable investment and innovation. In this case, a special function is required to ensure that the investment methods are compatible with long-term expansion.

References

1. 2020 Ends earth's warmest 10 years on record (2021). Met Office. [cited March 6, 2023]. Available at: https://www.metoffice.gov.uk/aboutus/press-office/news/weather-and-climate/2021/2020-ends-earths-warmest-10-years-on-record
2. Abbas, Q., & Chaudhry, I. S. (2017). 37, No. 1 (2017), pp. 102-113 Environmental Degradation and Economic Development Nexus in Pakistan: A Time Series Analysis. *Pakistan Journal of Social Sciences*, *37*(1), 102-113.
3. Abbas, Q., Khan, A. R., Bashir, A., Alemzero, D. A., Sun, H., Iram, R., & Iqbal, N. (2020). Scaling up renewable energy in Africa: measuring wind energy through econometric approach. *Environmental Science and Pollution Research*, *27*, 36282-36294. https://doi.org/10.1007/s11356-020-09596-1
4. Baloch, Z. A., Tan, Q., Iqbal, N., Mohsin, M., Abbas, Q., Iqbal, W., & Chaudhry, I. S. (2020). Trilemma assessment of energy intensity, efficiency, and environmental index: evidence from BRICS countries. *Environmental Science and Pollution Research*, *27*, 34337-34347. https://doi.org/10.1007/s11356-020-09578-3
5. Chaudhry, I.S., Yin, W., Ali, S.A., Faheem, M., Abbas, Q., Farooq, F., & ur Rahman, S. (2021). Moderating role of institutional quality in validation of pollution haven hypothesis in BRICS: a new evidence by using DCCE approach. *Environmental Science and Pollution Research, 29*, 9193-9202. https://doi.org/10.1007/s11356-021-16087-4
6. From the report of Belousov A.R. (2021). Official website of the Government of the Russian Federation. [cited December 25, 2022]. Available at: http://government.ru/news/43294/#energo (In Russ.)
7. Hao, W., Abbas, Q., Ahmad, I., Alharthi, M., Hanif, I., & Taghizadeh-Hesary, F. (2021). Institutional efficiency and utility reform performance: An evidence from electricity performance in South & East Asia. *Economic Analysis and Policy*, *72*, 549-561. https://doi.org/10.1016/j.eap.2021.09.013
8. Henderson, J., & Sen, A. (2021). *The Energy Transition: Key challenges for incumbent and new players in the global energy system* (No. 01). OIES Paper, ET.
9. Hordeski, M. F. (2020). *Megatrends for energy efficiency and renewable energy*. CRC Press. https://doi.org/10.1201/9781003151616
10. Kodaneva, S. I. (2022). Energy transition: Global trends and their consequences for Russia. *Contours of global transformations: Politics, Economics, Law, 15*(1), 167-185. https://doi.org/10.23932/2542-0240-2022-15-1-8 (In Russ.)
11. Kumaran, V.V., Ridzuan, A.R., Khan, F.U., Abdullah, H.B., & Mohamad, Z.Z. (2020). An Empirical Analysis of Factors Affecting Renewable Energy Consumption in Association of Southeast Asian Nations-4 Countries. *International Journal of Energy Economics and Policy*, *10,* 48–56. https://doi.org/10.32479/ijeep.8142
12. Lyu, Y., Ali, S. A., Yin, W., & Kouser, R. (2022). Energy Transition, Sustainable Development Opportunities, and Carbon Emissions Mitigation: Is the Developed World Converging Toward SDGs-2030? *Frontiers in Environmental Science*, *10,* 1016-1029. https://doi.org/10.3389/fenvs.2022.912479
13. Marshall, H. (2021). Net Zero Targets and GHG Emission Reduction in the UK and Norwegian Upstream Oil and Gas Industry: A Comparative Assessment. The Oxford Institute for Energy Studies. [cited March 1, 2023]. Available at: https://www.oxfordenergy.org/publications/net-zerotargets-and-ghg-emission-reduction-inthe-uk-and-norwegian-upstream-oil-andgas-industry-a-comparative-assessment
14. Marteau, J. (2021) From Paris to Glasgow and beyond: Towards Kazakhstan's carbon neutrality by 2060. World Bank. [cited March 6, 2023]. Available at: https://blogs.worldbank.org/europeandcentralasia/paris-glasgow-and-beyond-towards-kazakhstans-carbon-neutrality-2060

15. Razmjoo, A., Kaigutha, L.G., Rad, M.A., Marzband, M., Davarpanah, A., & Denai, M. (2021). A Technical analysis investigating energy sustainability utilizing reliable renewable energy sources to reduce CO2 emissions in a high potential area. *Renewable Energy*, *164*, 46–57. https://doi.org:/10.1016/j.renene.2020.09.042

16. Report (2022). Kazakhstan's Financial Stability Report 2021. [cited February 15, 2023]. Available at: https://nationalbank.kz/file/download/79672

17. Reuters (2019). Global Companies See Climate Change Hitting Their Bottom Lines in Next 5 Years. [cited March 3, 2023]. Available at: https://www.thehindubusinessline.com/economy/global-companies-see-climate-change-hitting-their-bottom-lines-innext-5-years/article27433152.ece

18. Roser, M. (2020). Why did renewables become so cheap so fast? And what can we do to use this global opportunity for green growth? Our World in Data. [cited February 26, 2023]. Available at: https://ourworldindata.org/cheap-renewables-growth

19. Shen, H., Ali, S. A., Alharthi, M., Shah, A. S., Basit Khan, A., Abbas, Q., & ur Rahman, S. (2021). Carbon-free energy and sustainable environment: The role of human capital and technological revolutions in attaining SDGs. *Sustainability*, *13*(5), 2636-2655. https://doi.org:/10.3390/su13052636

20. Specht, J. M., & Madlener, R. (2019). Energy Supplier 2.0: A conceptual business model for energy suppliers aggregating flexible distributed assets and policy issues raised. *Energy Policy*, *135*, 110911-110925. https://doi.org:/10.1016/j.enpol.2019.110911

21. Tracker, C. (2020). Coal developers risk $600 billion as renewables outcompete worldwide, London, New York: Carbon Tracker Initiative. [cited March 6, 2023]. Available at: https://carbontracker.org/coal-developers-risk600-billion-as-renewables-outcompeteworldwide

22. Wei, G., Asghar, N., Ahmad, I., Yin, W., Abbas, Q., ur Rahman, S., & Farooq, F. (2021). Economic growth, fiscal imbalance, and environmental sustainability: What is desirable and undesirable for developing economies?. *Environmental Science and Pollution Research*, *28*(37), 52283-52294. https://doi.org:/10.1007/s11356-021-14379-3

23. Worighi, I., Maach, A., Hafid, A., Hegazy, O., & Van Mierlo, J. (2019). Integrating renewable energy in smart grid system: Architecture, virtualization and analysis. *Sustainable Energy, Grids and Networks*, *18*, 100226-100239. https://doi.org:/10.1016/j.segan.2019.100226

24. Wu, S., Alharthi, M., Yin, W., Abbas, Q., Shah, A. N., Ur Rahman, S., & Khan, J. (2021). The carbon-neutral energy consumption and emission volatility: The causality analysis of asean region. *Energies*, *14*(10), 2943-2958. https://doi.org:/10.3390/en14102943

25. Zheng, Zh. (2021). Improving grid interconnection to support climate change mitigation. Oxford Energy Forum. [cited March 3, 2023]. Available at: https://www.oxfordenergy.org/publications/oxford-energy-forum-thegeopolitics-of-energy-out-with-the-oldand-in-with-the-new-issue-126/

Information about the authors

*** Bibigul S. Saubetova** – Cand. Sc. (Econ.), Acting Associate Professor, Department of Finance, Caspian university of technologies and engineering named after S. Yessenov, Aktau, Kazakhstan, email: bs.saubetova@mail.ru, ORCID ID: https://orcid.org/0000-0002-2451-0385

Gaukhar A. Saimagambetova – Cand. Sc. (Econ.), Associate Professor, Management department, Caspian university of technologies and engineering named after S. Yessenov, Aktau, Kazakhstan, email: gauhar1973@mail.ru, ORCID ID: https://orcid.org/0000-0002-7634-5166

Aigul I. Esturlieva – Cand. Sc. (Econ.), Acting Associate Professor, Economics department, Caspian university of technologies and engineering named after S. Yessenov, Aktau, Kazakhstan, email: aigul.yesturliyeva@yu.edu.kz, ORCID ID: https://orcid.org/0000-0001-5632-8134

Gulimay D. Amaniyazova – Cand. Sc. (Econ.), Professor, Economic department, Caspian university of technologies and engineering named after Sh.Yessenov, Aktau, Kazakhstan, email: gulimai_a@mail.ru, ORCID ID: http://orcid.org/0000-0001-8605-0372

Авторлар туралы мәліметтер

***Саубетова Б.С.** – э.ғ.к., қауымдастырылған профессор м.а., «Қаржы» кафедрасы, Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Ақтау, Қазақстан, email: bs.saubetova@mail.ru, ORCID ID: https://orcid.org/0000-0002-2451-0385

Саймагамбетова Г.А. – э.ғ.к., доцент, «Менеджмент» кафедрасы, Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Ақтау, Қазақстан, email: gauhar1973@mail.ru, ORCID ID: https://orcid.org/0000-0002-7634-5166

Естурлиева А.И. – э.ғ.к., қауымдастырылған профессорының қ.а., «Экономика» кафедрасы, Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті, Ақтау, Қазақстан, email: aigul.yesturliyeva@yu.edu.kz, ORCID ID: https://orcid.org/0000-0001-5632-8134

Аманиязова Г.Д. – э.ғ.к., профессор, «Экономика» кафедрасының, Ш.Есенов атындағы Каспий т ехнологиялар және инжиниринг университеті, email: gulimai_a@mail.ru, ORCID ID: https://orcid.org/0000-0001-8605-0372

Сведения об авторах

***Саубетова Б.С.** – к.э.н., и.о. ассоциированного профессора, кафедра «Финансы», Каспийский университет технологий и инжиниринга имени Ш.Есенова, Актау, Казахстан, email: bs.saubetova@mail.ru, ORCID ID: https://orcid.org/0000-0002-2451-0385

Саймагамбетова Г.А. – к.э.н., доцент, кафедра «Менеджмент», Каспийский университет технологий и инжиниринга имени Ш.Есенова, Актау, Казахстан, email: gauhar1973@mail.ru, ORCID ID: https://orcid.org/0000-0002-7634-5166

Естурлиева А.И. – к.э.н., и.о.ассоциированный профессора, кафедра «Экономика», Каспийский университет технологий и инжиниринга имени Ш.Есенова, Актау, Казахстан, email: aigul.yesturliyeva@yu.edu.kz, ORCID ID: https://orcid.org/0000-0001-5632-8134

Аманиязова Г.Д. – к.э.н., профессор, кафедра «Экономика», Каспийский университет технологий и инжиниринга имени Ш.Есенова, Актау, Казахстан, email: gulimai_a@mail.ru, ORCID ID: https://orcid.org/0000-0001-8605-0372