DOI: https://doi.org/10.34069/AI/2023.67.07.31
How to Cite:
Niyazbekova, S., Balova, S., Bulakbay, Z., Maisigova, L., & Troyanskaya, M. (2023). Analysis of trends in the financial sector of the global fuel and energy complex. *Amazonia Investiga*, *12*(67), 352-373. https://doi.org/10.34069/AI/2023.67.07.31

Analysis of trends in the financial sector of the global fuel and energy complex

Análisis de las tendencias del sector financiero del complejo mundial de combustibles y energía

Received: June 20, 2023 Accepted: July 23, 2023

Written by:
Shakizada Niyazbekova[1]
https://orcid.org/0000-0002-3433-9841
Suzana Balova[2]
https://orcid.org/0009-0004-7167-6726
Zhanat Bulakbay[3]
https://orcid.org/0000-0002-3742-6756
Leila Maisigova[4]
https://orcid.org/0000-0003-2148-4924
Marija Troyanskaya[5]
https://orcid.org/0000-0003-4545-3786

Abstract

Understanding the global impact of energy on the economy and the financial sector is crucial for improving their interaction, especially within the fuel and energy complex (FEC). This study aims to identify the primary investment drivers for the financial sector within the FEC. It incorporates opinions, conclusions, and forecasts from leading international organizations that monitor the financial sector and the FEC. Through comprehensive analysis, key investment drivers were identified, including renewable and nuclear energy, risks associated with nuclear energy usage, and the impact of traditional fossil fuel sources. The analysis revealed distinct clusters of investment drivers that shape the future development of the financial sector within the FEC. The study determined the rank, median, and relative ranking of investment attractiveness for each cluster and investment vector. This information is valuable for finance and economics specialists and holds scientific significance for experts studying

Resumen

Comprender el impacto global de la energía en la economía y el sector financiero es crucial para mejorar su interacción, especialmente dentro del complejo de combustibles y energía (FEC, por sus siglas en inglés). Este estudio tiene como objetivo identificar los principales impulsores de inversión para el sector financiero dentro del FEC. Se incorporan opiniones, conclusiones y pronósticos de las principales organizaciones internacionales que monitorean el sector financiero y el FEC. A través de un análisis exhaustivo, se identificaron los principales impulsores de inversión, que incluyen energía renovable y nuclear, los riesgos asociados con el uso de la energía nuclear y el impacto de las fuentes tradicionales de combustibles fósiles. El análisis reveló distintos grupos de impulsores de inversión que moldean el desarrollo futuro del sector financiero dentro del FEC. El estudio determinó el rango, la mediana y la clasificación relativa de la atracción de inversión

[1] Ph.D. in Finance. Money Circulation and Credit, Associate Professor, Senior Researcher at the Scientific and Educational Center Sustainable Development, Moscow Witte University, Moscow, Russian Federation; Associate Professor at the Department of Banking and Financial Markets, Financial University under the Government of the Russian Federation, Moscow, Russian Federation. Researcher ID: E-7112-2015
[2] Ph.D. in Economics, Associate Professor at the Logistics and Marketing Department, Financial University under the Government of the Russian Federation, Moscow, Russian Federation. Researcher ID: CFA-6323-2022
[3] Ph.D. in Economics, Associate Professor, Associate Professor at the Finance Department, L.N.Gumilyov Eurasian National University, Nur–Sultan, Republic of Kazakhstan. Researcher ID: ITU-5101-2023
[4] Ph.D. in Economics, Associate Professor at the Department "Accounting, Analysis and Audit", Ingush State University, Magas, Russian Federation. Researcher ID: AAD-3063-2020
[5] Doctor of Economics, Associate Professor, Head of the Department of State and Municipal Administration, Orenburg State University, Orenburg, Russian Federation. Researcher ID: F-1395-2015

globalization and energy sector trends. The complex cluster analysis used provides a structured system of potential investment drivers for the development of the financial sector within the FEC. This framework is applicable to related studies relying on expert opinions and forecasts.

Keywords: global, trend, driver, financing, energy, future.

para cada grupo y vector de inversión. Esta información es valiosa para especialistas en finanzas y economía, y tiene una importancia científica para expertos que estudian las tendencias de globalización y del sector energético. El análisis de grupos complejos utilizado proporciona un sistema estructurado de posibles impulsores de inversión para el desarrollo del sector financiero dentro del FEC. Este marco es aplicable a estudios relacionados que se basan en opiniones y pronósticos de expertos.

Palabras clave: global, tendencia, impulsor, financiamiento, energía, futuro.

Introduction

The design and implementation of strategies for the development of the fuel and energy complex (FEC) are currently facing a number of challenges, including global climate change, reduced availability of certain energy resources, increased consumption, etc. These challenges directly affect the financial sector of the FEC, which is a key factor in the investment and development of the industry. In this regard, the study of trends in the financial sector of the global FEC is highly relevant (Marhasova et al., 2020; Polishchuk, Kornyliuk, Lopashchuk & Pinchuk, 2020; Nurpeisova et al., 2020). The first reason why the study of trends in the financial sector of the global fuel and energy complex is relevant is that this sector is an integral part of the global economy. It includes large international companies engaged in the extraction, production and sale of energy resources, as well as financial institutions providing financial services and investing in the industry. Therefore, an analysis of trends in the development of the financial sector of the fuel and energy sector allows us to assess its contribution to the economy and identify opportunities for its development and efficiency improvement (Sotnyk et al., 2021; Shkola et al., 2021; Shpak et al., 2022).

The second reason why the study of trends in the financial sector of the global fuel and energy complex is relevant is that this sector is a link between energy companies and investors. An analysis of trends in the financial sector of the fuel and energy complexmakes it possible to identify opportunities for investing in the industry and assess the risks associated with investments. This can be an important factor for decision-making by investors and other market participants (Niyazbekova et al., 2021; Kerimkulova et al., 2021; Kolodii et al., 2019; Khutorna et al., 2021; Jalgasovna, Abduvakhabovna & Ramizitdinovna, 2023).

The third reason why the study of trends in the development of the financial sector of the global FEC is relevant is that this sector has a significant impact on the environment and climate change, as it is associated with the production and consumption of energy resources. An analysis of trends in the financial sector of the fuel and energy sector makes it possible to assess the environmental risks and opportunities associated with investing in the industry and to take measures to reduce the negative impact on the environment (Tulchynska et al., 2021; Manigandan et al., 2023; Ali, Jianguo & Kirikkaleli, 2023; Prokopenko & Shkola, 2012).

The fourth reason why the study of trends in the financial sector of the global fuel and energy complex is relevant is that the existing instability in the world markets is largely related to energy-related industries such as oil, gas, and coal. Analyzing trends in the financial sector of the fuel and energy sector will help predict possible changes in the market and develop strategies to minimize risks and maximize profits (Abbas et al., 2023; Zioło, 2023; Achuo, Kakeu, & Asongu, 2023).

The fifth reason why the study of trends in the financial sector of the global fuel and energy complex is relevant is geopolitical risks. Geopolitical risks in the FEC may have various implications for the financial sector, including reduced access to capital, changes in market dynamics and changes in tariff policies. Also, such risks could lead to increased market competition and a change in the global balance of power (Dong et al., 2023; Ha, 2023; Chishti, Sinha, Zaman & Shahzad, 2023).

Therefore, an analysis of trends in the development of the global FEC financial sector in the context of geopolitical risks is critical to

understanding the global market situation and making informed investment decisions. The research can help investors and other stakeholders to take measures to minimize risks and protect their interests in the context of uncertainty and instability in the world markets.

In general, the study of trends in the development of the financial sector of the global fuel and energy complex is important for understanding the current state of the industry, assessing its potential and risks associated with investment, as well as for developing strategies for sustainable development and environmental protection.

The purpose of the study is to establish the financial drivers of the present and future development of the global FEC, considering the actual financial and economic picture of the world.

Research Objectives:

1. Analysis of the scientometric landscape regarding the links and mutual influence of the financial sector and the FEC.
2. Analysis of expert opinions, conclusions and forecasts regarding the development of the financial sector of the fuel and energy complex.
3. Establishment of probable drivers for the development of the financial sector of the fuel and energy complex.

The study on the financial drivers of the development of the global fuel and energy complex has both scientific and practical value. The scientific value lies in the identification of financial factors affecting the development of the fuel and energy complex and in their detailed analysis. This allows to deepen the understanding of the mechanisms of functioning of the FEC and to develop new theoretical approaches to the development of the industry. The practical significance of the research is that it allows identifying the most effective strategies for FEC development based on financial drivers. The analysis of financial factors also allows identifying the financial risks associated with the development of the fuel and energy complex, and to develop measures to reduce them. The results obtained can be used in the development of public policy and business strategies in the FEC industry, as well as for investment and decision-making in the financial markets.

Theoretical Framework or Literature Review

Let us analyze the relevant and current publications of the leading scientometric databases on current trends in the financial sphere of the fuel and energy complex.

A study Colenbrander et al., (2023) found that the transition to a low-carbon economy could pose significant risks to India's financial system due to the changing geopolitical situation, declining demand for oil and gas, climate change, and rising health and security risks.
To mitigate the risks, it is recommended that sustainable development strategies include economic diversification, investment in clean energy and energy efficiency, and active engagement with the international community for financial support.

According to a study by Nibedita and Irfan (2023), energy diversity in the E7 economies lowers carbon emissions, especially when renewable energy is used.

However, dependence on coal, oil, and gas, as well as the high cost of investing in clean energy sources, can weaken the link between energy diversification and carbon reduction. Successful diversification requires sustainable development strategies that include investment in renewable energy, energy efficiency, and infrastructure improvements. The results of the study can be useful for investment decisions and sustainability strategies in E7 economies and elsewhere.

A new model, MATRIX (Multi-Agent Model for Transition Risks with Application to Energy Shocks), is presented in the research Ciola et al., (2023) to evaluate the risks associated with the transition to a low-carbon economy while accounting for energy shocks.

The main conclusions of the study are related to the application of the model to two countries - Italy and France - namely to the identification of risks associated with oil and gas market instability. The simulation results showed that the transition to a low-carbon economy can reduce the dependence on oil and gas and reduce the risks associated with the price volatility of these resources. It was also found that there is a difference in dependence on oil and gas between Italy and France, which emphasizes the need for an individual approach to each country. Overall, the study (Ciola et al., 2023) demonstrates that the development of integrated models can be useful for investment decisions and sustainable development strategies.

Using the UK as a case study, Caglar (2023) examines the importance of the nuclear budget in the shift to a low-carbon economy.

The study finds that increasing the budget for nuclear power can facilitate the transition to a low-carbon economy, especially in an environment where other renewable energy sources are not yet commercially viable. However, the risks associated with nuclear power, such as unforeseen accidents and the high costs of storing radioactive waste, must be considered. The results of the study may be useful for sustainability strategies in other countries, especially those with few renewable energy sources.

The relationship between macroeconomic and financial policies and climate change is examined in a study by Azam, Hunjra, and Taskin (2023).

The results of the study show that macroeconomic policies such as credit, fiscal and monetary policies have a large impact on carbon emissions and climate change. It also found that financial policies, such as investments in renewable energy and sustainable technologies, can reduce carbon emissions and have a positive impact on climate change. The study highlights the need to integrate macroeconomic and financial policies to achieve sustainable development and reduce the impact on climate change. The results can be useful for designing sustainable development strategies and macroeconomic policies that contribute to reducing carbon emissions and combating climate change.

Anu, Singh, Raza, Nakonieczny, and Shahzad (2023) conducted research on the impact of energy efficiency, green innovation, and financial inclusion on environmental productivity in both developed and developing economies. The results of the study show that financial inclusion, green innovation and energy efficiency have a positive impact on environmental productivity in both types of economies. However, these factors have a stronger impact on environmental productivity in developing economies than in developed economies. The results of the study underscore the need for measures to support financial inclusion, green innovation, and energy efficiency in both types of economies, especially in developing economies, in order to achieve sustainable development.

The relationship between money and the dangers related to climate change is examined in a study by Borio, Claessens, and Tarashev (2023). The authors note that the financial sector can play an important role in addressing climate change, but only if it manages expectations and takes action to reduce risks. The authors emphasize the need to better assess climate risks and to develop standards for accounting for these risks in financial reporting. It was also found that taking action to reduce climate change risks can lead to new opportunities for the financial sector, including in renewable energy, green bonds and other green investments. The results of the study can be useful for designing sustainability strategies that take into account the financial aspects of combating climate change.

The study Jia (2023) analyzes the impact of green financial policies on the level of decarbonization of economies using the examples of the United States, China and Russia. The results of the study show that green financial policies have a positive impact on the level of decarbonization of economies in all three countries. However, China is a leader in the implementation of green financial policies, while the U.S. and Russia are lagging behind in this aspect. The study emphasizes the need to strengthen green financial policies in all countries in order to achieve higher levels of decarbonization and combat climate change. The results of the study can be useful for the development of sustainable development strategies based on green financial policies.

Using agent-based integrated evaluation models, Naumann-Woleske (2023) proposes new techniques for evaluating the environmental effects of economic and energy policy. The author notes that agent-based models are more flexible and adaptive than traditional integrated models because they take into account a wider range of variables and interactions between them. It was also found that agent-based models can help in making more accurate economic and energy policy decisions that will contribute to more sustainable development and combat climate change. The results of the study can be useful for the development of sustainable development strategies based on agent-based models.

A study Xu et al., (2023) presents a new method for reconstructing international energy trade networks based on given marginal data. The authors apply graph theory to analyze the network structures of international energy trade flows, including oil, gas, and coal, in order to

identify the most significant nodes and links in these networks. The study shows that energy trade networks have a significant impact on the global economy and environment, and that their analysis can help make better decisions about energy policy and combating climate change. The results of the study can be useful for developing sustainable development strategies that take into account international energy trade flows and their impact on the environment.

Summarizing the results of the research, several key financial drivers for the development of the global fuel and energy complex can be identified. One of them is the transition to a low-carbon economy, which is becoming increasingly important considering the climate change problem. Another important driver is the financial involvement in the development of alternative energy sources, such as solar and wind energy, which are becoming more competitive every year. Geopolitical risks and sanctions, including those against the Russian fuel and energy complex, also have a significant impact on the development of the fuel and energy complex. Of great importance are financial risk analysis tools, such as risk assessment models and integrated assessment models, which make it possible to assess the impact of various factors on the development of the fuel and energy complex and to predict possible risks. In general, the financial drivers of global FEC development are becoming increasingly complex and multidimensional, requiring more in-depth analysis and the development of new strategies for sustainable development.

Methodology

The following methods were used to achieve the goal and objectives of this study:

1. Correlation analysis regarding the mutual influence of the financial sector and the fuel and energy complex: correlation analysis is used to study the relationship between the financial sector and the fuel and energy complex. This method allows us to assess the degree of dependence between different variables and determine which of them influence the others. Correlation analysis is applied to identify the relationship between financial investments and investments in the fuel and energy sector, as well as to determine which factors may influence the development of these sectors in the future.
2. Method of assessment and analysis of expert opinions, conclusions and forecasts concerning the current state and probable scenarios of development of the FEC financial sector: this method allowed to analyze the works of leading expert organizations, which perform analytical and statistical research of the FEC financial sector. The results obtained were used to analyze the current situation, identify possible risks and trends, as well as to forecast the future development of this sector. This method is an important tool for making strategic decisions and developing action plans in the financial sector of the FEC.
3. Correlation analysis of forecast data of leading expert organizations of the financial sector of the fuel and energy complex: this method provided an opportunity to establish probabilistic drivers of development of the financial sector of the fuel and energy complex, such as changes in the regulatory environment, increased investment in clean energy and growth of demand for alternative energy sources. This method allows us to more accurately assess the likelihood of future trends in the development of the financial sector of the fuel and energy complex and to make appropriate decisions in risk management.

The expert basis, the analytical data of which were used in this study, was formed on the basis of the works of the following specialized organizations Table 1.

Table 1.
Brief characteristics of expert organizations.

Name of organization	Brief description and reference
International Energy Agency (*IEA*)	*The International Energy Agency* (*IEA*) is a key international agency that analyzes and forecasts the global energy market, including various aspects related to production, consumption, security and the environment. IEA is an authoritative source of information for many countries and regions, including the financial sector, which can use IEA forecasts and analysis when making decisions about investing in the fuel and energy sector. In addition, the IEA also provides valuable information and guidance on energy efficiency, increased use of renewable energy and reductions in greenhouse gas emissions, which can be useful for investors who are focused on financing environmentally friendly projects in the FEC. (https://www.iea.org/).
International Renewable Energy Agency (*IRENA*)	*The International Renewable Energy Agency* (*IRENA*) is an international agency established in 2009 to facilitate the development and promotion of renewable energy sources (RES) worldwide. IRENA is a global platform for international cooperation with more than 160 member states, including the European Union. It promotes the exchange of knowledge and transfer of experience in the development and implementation of new technologies, increasing the efficiency and affordability of renewable energy, and supports the development and implementation of strategies and policies in the field of renewable energy. As part of its activities, *IRENA conducts* analytical research, including in the field of economics, finance and investment in renewable energy, which makes it a significant source of information and analysis for financial sector analysts in the fuel and energy sector dealing with investment in renewable energy (https://www.irena.org/).
World Economic Forum (WEF)	*World Economic Forum* (*WEF*) is an international organization that conducts research, organizes conferences and forums aimed at solving global economic and social problems. WEF is also a center for the exchange of views between business leaders, government officials, experts and academics, as well as representatives of international organizations. In the context of financial sector analysis of the energy sector, *WEF* conducts research and analyzes trends regarding investments and sustainable development in the energy industry. The organization also considers various aspects of energy policy, including the transition to cleaner energy sources, energy efficiency and risk management in relation to climate change. Drawing on its expertise and network of contacts, *WEF* acts as a platform for the exchange of experience between stakeholders who work in the financial sector of the fuel and energy sector and strive for sustainable and innovative development of the industry (https://www.weforum.org/).
Organisation for Economic Co-operation and Development (*OECD*)	*The Organisation for Economic Co-operation and Development* (*OECD*) is an international organization established to coordinate economic policy and cooperation among its member states. In the context of financial sector analysis of the fuel and energy sector, the OECD researches and analyzes energy sector policy and regulation, including issues of energy security, efficiency, innovation and environmental sustainability. The organization provides data and analytical reports that help member states make effective energy decisions, including the financing of FEC projects. *The OECD* also engages in international cooperation and exchange of experience in the field of energy and finance (https://www.oecd.org/).
International Monetary Fund (*IMF*)	*The International Monetary Fund* (*IMF*) is an international organization whose main purpose is to ensure global financial stability and promote international trade by coordinating monetary policies and providing financial support. In the context of analyzing the financial sector of the fuel and energy sector, *IMF* has a number of publications and reports that analyze the impact of financial risks on the economic growth and stability of countries, including those dependent on oil and gas exports. *IMF* reports also include analyses of economic policy, regulation and measures to reduce greenhouse gas emissions that are important for the development of the fuel and energy sector (https://www.imf.org/).
United Nations (*UN*)	*United Nations* (*UN*) is an intergovernmental organization established to maintain peace, security and cooperation between nations. In the context of financial sector analysis of the FEC, the UN acts as a facilitator of coordination and regulation of the international financial system. The UN is also active in sustainable development issues, including the development and implementation of programs to reduce carbon emissions and improve access to clean energy. As part of its programs, the UN works with the financial sector, including international financial institutions, to support projects and programs related to sustainable development, energy efficiency, and greenhouse gas reduction (https://www.un.org/).

World Bank (*WB*)	*The World Bank* (*WB*) is an international financial institution established to provide financial and technical assistance to developing countries in order to fight poverty and improve living standards. In the context of financial sector analysis of the fuel and energy sector, the World Bank is an important source of financing for energy and climate change projects. It also provides expertise in developing energy strategies and policies, as well as training in these areas (https://www.worldbank.org/).
European Bank for Reconstruction and Development (*EBRD*)	*The European Bank for Reconstruction and Development* (*EBRD*) is an international financial institution established to support market reforms and democratic transition in Central and Eastern Europe, the Caucasus, and Central Asia. The EBRD works in various sectors, including energy, and actively supports the development of renewable energy projects in the region. It also provides financial and technical assistance to companies involved in the production of energy technology and equipment. In the context of FEC financial sector analytics, *EBRD* is an important source of data and information on energy and climate projects and investments in the region, and plays an important role in supporting the financing of energy projects (https://www.ebrd.com/).
Energy Information Administration (*EIA*)	*The Energy Information Administration* (*EIA*) is the U.S. government's energy information agency that collects, analyzes and disseminates information on energy policy, consumption and production in the United States and around the world. *EIA* provides statistics, forecasts, and analysis that can be useful to financial sector analysts of the FEC as they can be used to forecast energy demand, energy prices, and changes in the structure of the energy sector (https://www.eia.gov/).
European Commission	*The European Commission* (*EC*) is the executive body of the European Union, which is responsible for developing legislative proposals, monitoring the implementation of laws and managing the budget. In the context of financial sector analysis of the FEC, *the EU* works to develop and implement policies to promote savings, reduce greenhouse gas emissions and stimulate investment in cleaner technologies and production. *The EU* also works in the field of energy efficiency, supporting measures aimed at reducing energy consumption in industry, construction and transport. In addition, *the EU* develops rules and regulations to collect, analyze and disseminate information on energy use and greenhouse gas emissions (https://commission.europa.eu/).

Source: Created by the author based on public data

The use of data from leading industry organizations, such as IEA, IRENA, WEF, OECD, IMF, UN, WB, EBRD, EIA and EU, in the analysis of the FEC financial sector provides meaningful information for decision-making in the field of investment, development and industry regulation. Each of these organizations contributes to the analysis of the financial condition and development prospects of the FEC by providing data on the current situation, trends and forecasts in the industry. Through the use of these organizations' data, financial institutions and companies can make better-informed decisions, taking into account the prospects for industry development and the risks associated with climate change and the transition to cleaner and more sustainable energy sources.

Results and Discussion

The global economy is experiencing a steady growth in energy consumption based on high levels of industrialization, rapid population growth, and increasing economic activity in various regions of the world. Constantly growing energy consumption is an important component of economic development, especially in developing countries. Energy is a key factor of production in many sectors of the economy, such as industry, transport and housing. Moreover, population growth and rising living standards also lead to increased energy consumption as people need more energy to meet their needs (Rode al., 2021; Hassan, Wang, Khan & Zhu, 2023; Doytch, Elheddad & Hammoudeh, 2023) - Figure 1, Figure 2.

Increasing global energy consumption, especially through the use of fossil fuels, leads to increased emissions of harmful substances such as carbon dioxide, nitrogen oxides, and sulfur oxides into the atmosphere, resulting in global climate change and air pollution. These emissions are the main cause of the greenhouse effect, which leads to dramatic climate change, as well as deterioration of air quality, human health, and ecosystems. In addition, the extraction and use of fossil fuels can also lead to the pollution of water resources, soil, and the ecological destruction of natural animal habitats. These negative effects underscore the need to develop sustainable and clean energy sources as well as improve energy efficiency to reduce overall energy consumption and environmental

harm (Khan, Zakari, Dagar & Singh, 2022; Al-Shetwi, 2022; Adebayo et al., 2023). Figure 3.

Global energy consumption, which is provided by the fuel and energy complex (FEC), strongly influences climate change, especially global warming. Emissions of greenhouse gases such as carbon dioxide, methane, and nitrogen oxide, which are emitted during the extraction, transportation, production, and combustion of fossil fuels, lead to an increase in these gases in the atmosphere. This in turn leads to an increase in Earth's surface temperature and climatic changes such as area droughts, area floods, changes in the world's oceans, etc. Global warming can also destroy ecosystems and threaten human health. Therefore, it is becoming increasingly important to reduce greenhouse gas emissions and switch to renewable energy sources (Colgan & Hinthorn, 2023; Ballal, Cavalett, Cherubini & Watanabe, 2023; He, Khan, Ozturk & Murshed, 2023). Figure 4.

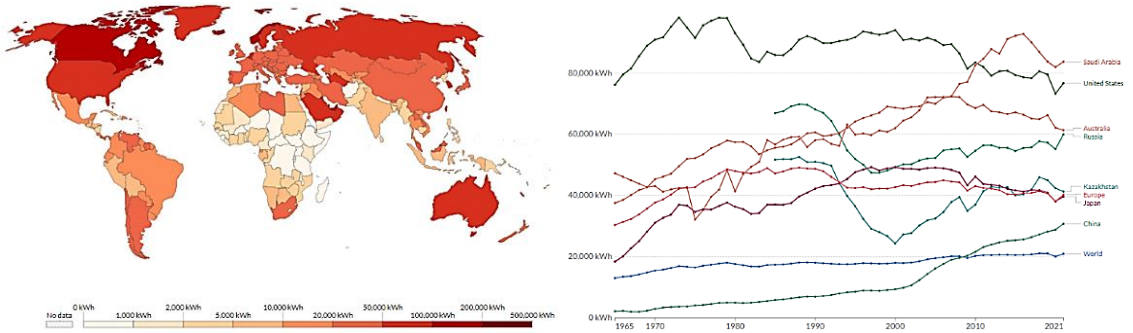

Figure 1. Growth dynamics of specific energy consumption (kWh/person)
Source: Our World in Data (2023a)

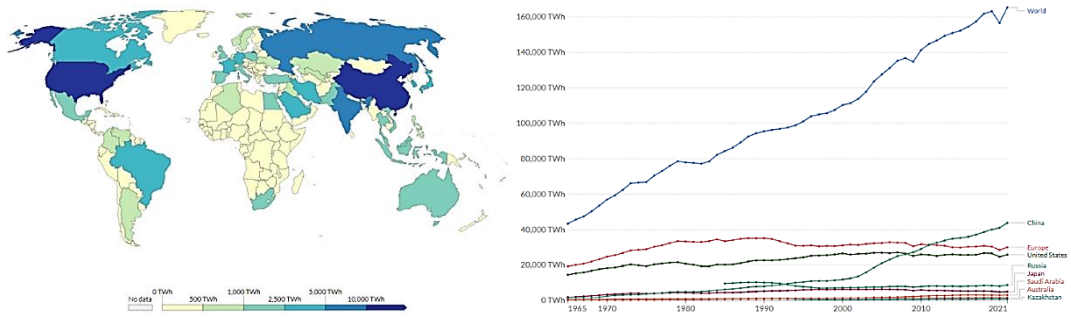

Figure 2. Global energy consumption growth in absolute units (TWh)
Source: Our World in Data (2023a)

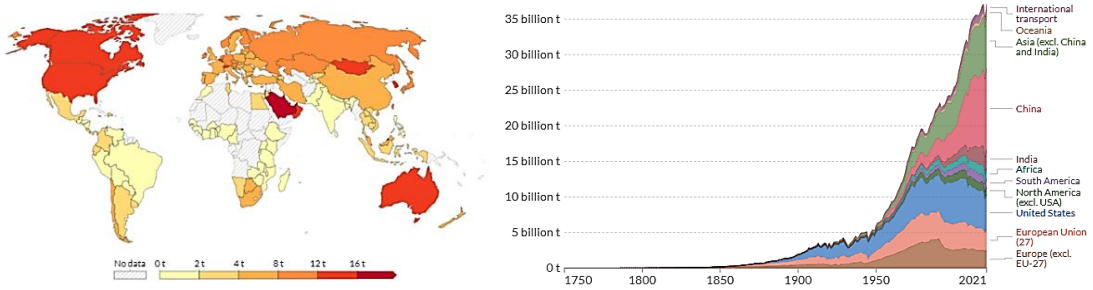

Figure 3. Dynamics of carbon dioxide emissions increase.
Source: Our World in Data (2023b)

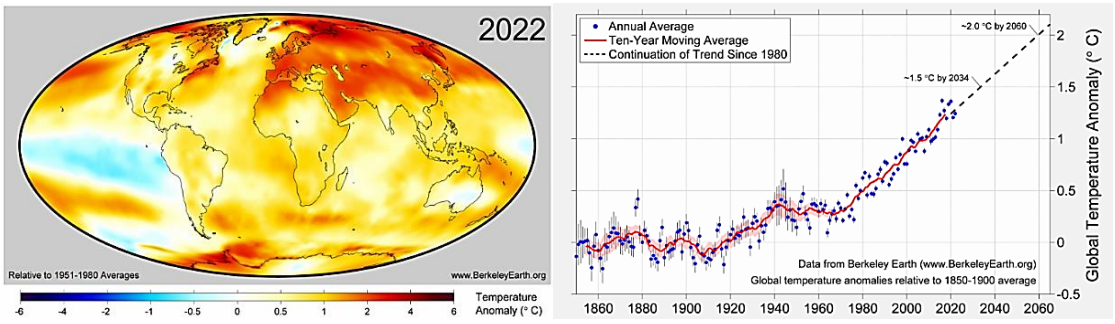

Figure 4. Evidence of Climate Change: The Dynamics to Increase Global Temperature on the Planet (Actual and Projected Figures)
Source: Berkeley Earth (2021)

The problem of climate change has forced the world community to take action. International agreements to reduce greenhouse gas emissions have been signed to combat climate change.

One such agreement is the Kyoto Protocol, adopted in 1997. It provided for a 5.2% reduction in greenhouse gas emissions by 2012 compared to 1990 levels. However, the U.S. did not join the agreement, and some countries, including Russia, withdrew from it after the first period. In 2015, the Paris Agreement was signed, in which more than 190 countries agreed to reduce greenhouse gas emissions and set a goal of limiting global temperature growth to no more than 2 degrees Celsius above pre-industrial levels. Each country must develop its own national action plan to achieve this goal. Various international organizations and programs, such as the Global Environment Facility, Green Climate Fund, and Carbon Disclosure Project, have also been created to support and encourage efforts to reduce greenhouse gas emissions and switch to cleaner technologies. Despite this, reducing greenhouse gas emissions remains a pressing issue, as many countries continue to depend on energy sources that significantly pollute the environment. A number of countries have now adopted policies to reduce man-made gas emissions, Net Zero (Cheng, Luo, Jenkins & Larson, 2023; Wang et al., 2023; Groves, Santosh & Zhang, 2023). Figure 5.

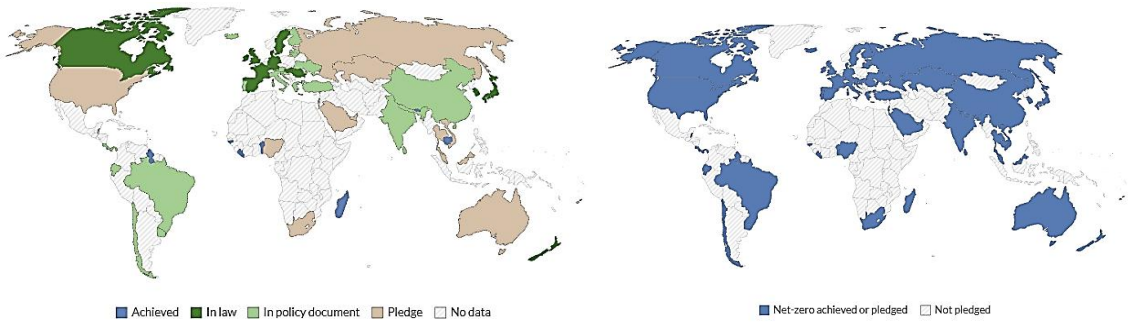

Figure 5. Current status of countries in relation to *Net Zero* policy.
Source: Our World in Data (2023b)

Considering the growing problem of climate change and the growing awareness of the need to reduce greenhouse gas emissions, the global community has come to the conclusion that energy from fossil sources must be gradually replaced by energy from renewable sources. Renewable sources are defined as energy sources that use endless natural resources, such as solar, wind, hydropower, geothermal energy, and others. These energy sources reduce dependence on fossil fuels, reduce greenhouse gas emissions and reduce the environmental impact. In addition, the use of renewable energy sources allows for a more stable energy future and reduces the geopolitical risks associated with the extraction and transportation of fossil fuels. Many countries are currently developing and implementing programs to transition to renewable energy, and this is an important step in combating climate change (Sayed et al., 2023; Siddik et al., 2023; Hossain et al., 2023). Figure 6 - Figure 8.

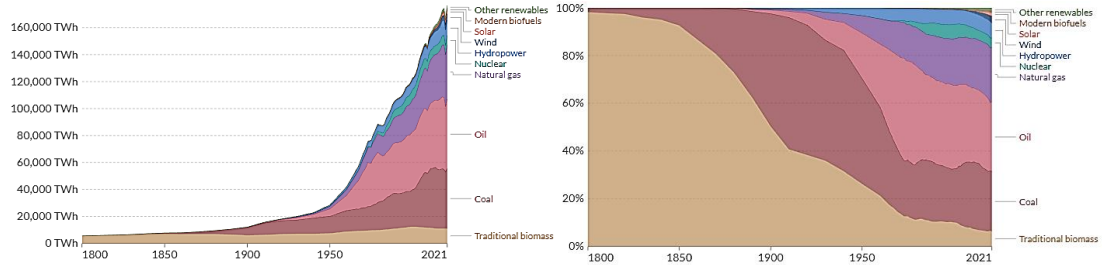

Figure 6. Dynamics of the global energy balance.
Source: Our World in Data (2023a)

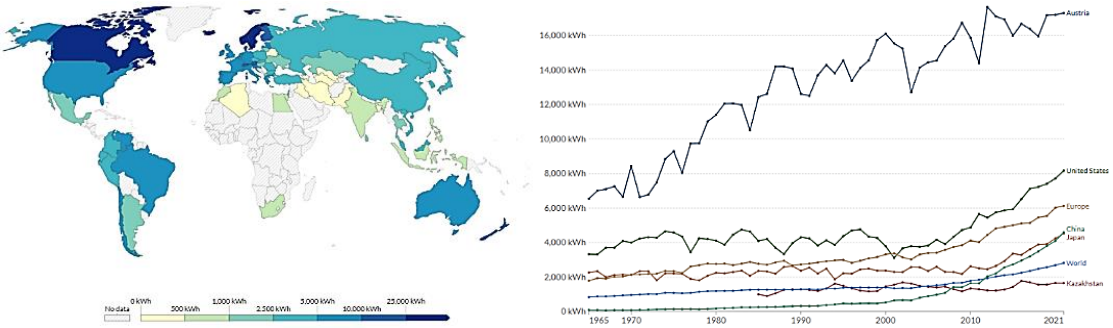

Figure 7. The dynamics of specific energy consumption from renewable energy sources (kWh/person)
Source: Our World in Data (2023a)

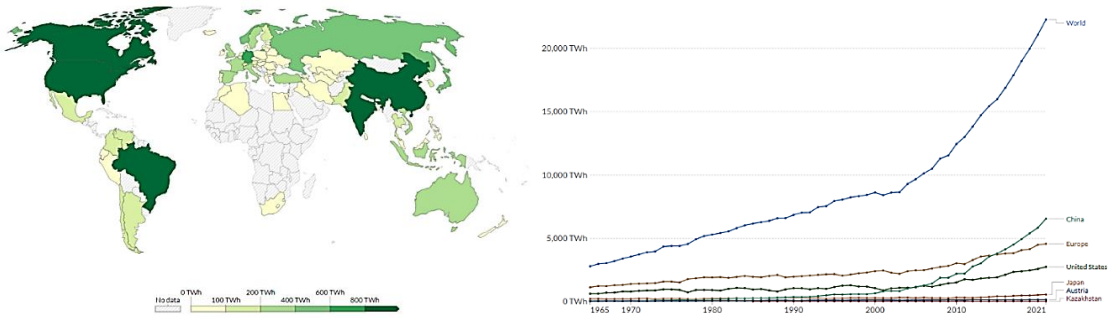

Figure 8. Dynamics of global energy consumption from renewable sources in absolute units (TWh)
Source: Our World in Data (2023a)

The issue of nuclear power raises mixed reactions in the global community. On the one hand, nuclear power is considered one of the most environmentally friendly energy sources that do not produce greenhouse gases. In addition, this energy is relatively cheap and provides a high level of reliability of electricity supply. On the other hand, the risks of nuclear accidents, including the 1986 Chernobyl disaster, raise serious safety concerns. In addition, the issue of disposal of radioactive waste, which has retained its radioactivity for thousands of years, is a problem for many countries. Despite these concerns, many countries continue to use nuclear power, while others are trying to reduce their dependence on it in favor of renewable energy sources. Consequently, the global community continues to debate the future of nuclear power and tries to find the best balance between its potential benefits and risks (Sadiq et al., 2023; Simionescu, 2023, Chen, Jiang, Wang, & Wang, 2023) Figure 9.

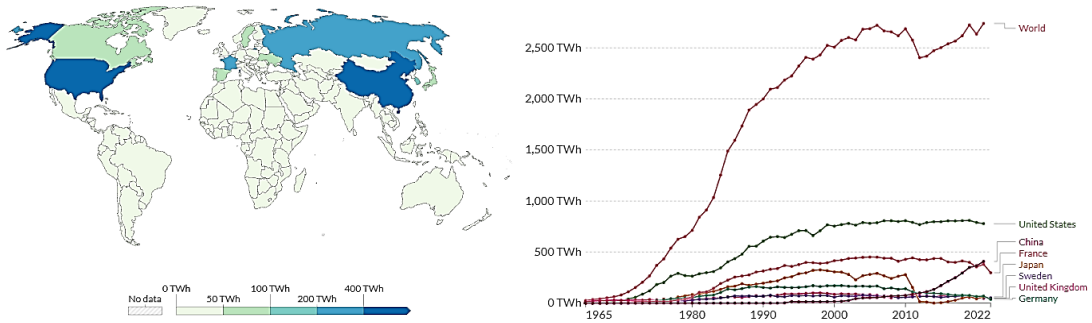

Figure 9. Dynamics of nuclear power development
Source: Our World in Data (2023a)

The Covid-19 pandemic has had a significant impact on the global fuel and energy complex. Measures to control the spread of the virus have reduced energy consumption in many countries, leading to a drop in oil and gas prices and a reduction in energy production and extraction.

At the same time, the crisis caused an increase in investment in renewable energy and stimulated the development of new technologies, such as digitalization and energy storage technology. In addition, the pandemic has caused changes in consumer habits, such as an increase in the proportion of working from home and a decrease in travel, which has also affected energy demand (Gollakota & Shu, 2023; Alam et al., 2023; Bhattacharya & Bose, 2023) Figure 10.

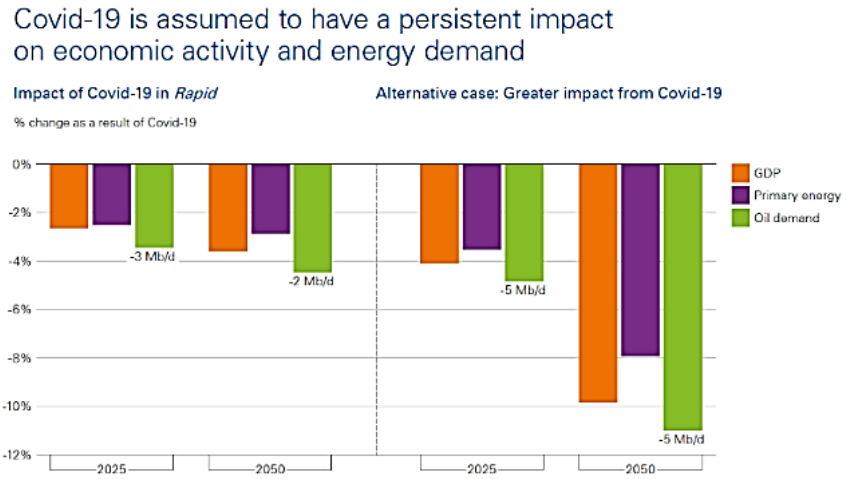

Figure 10. Assessing the impact of pandemic restrictions in the short and long term.
Source: WEF (2020)

Thus, the analysis of open sources data allows us to draw conclusions about the main drivers of the current and future development of the economic sector of the fuel and energy complex (Figure 11):

1. First Rank Drivers - Reasons:

a. Emission of man-made gases into the environment.
b. Global climate change.
c. Pandemic Constraints.
d. The global economic crisis.
e. Nuclear power.
f. Armed aggression and military conflicts.

2. Second-order drivers - solutions:

a. Renewable energy, energy conservation, energy efficiency.
b. Decarbonization Policy and *Net Zero*.
c. International agreements in the field of energy cooperation.
d. Monitoring and management.
e. Sanctions against aggressor countries.

3. Third rank drivers - monitoring, analysis, forecasts (interrelated actions affecting the functioning and development of the financial sector of the FEC):

a. Investments in renewable energy and *Net Zero* technology.
b. Investments in modernization, research and digitalization of the energy sector.
c. Investments in energy markets.

The presented driver system (Figure 11) contains a wide nomenclature of factors and aspects of functioning and development of the financial sector of the fuel and energy complex, while setting the most probable trends of development of the financial sector of the global fuel and energy complex based on expert opinions and forecasts of the previously defined expert environment (Table 1).

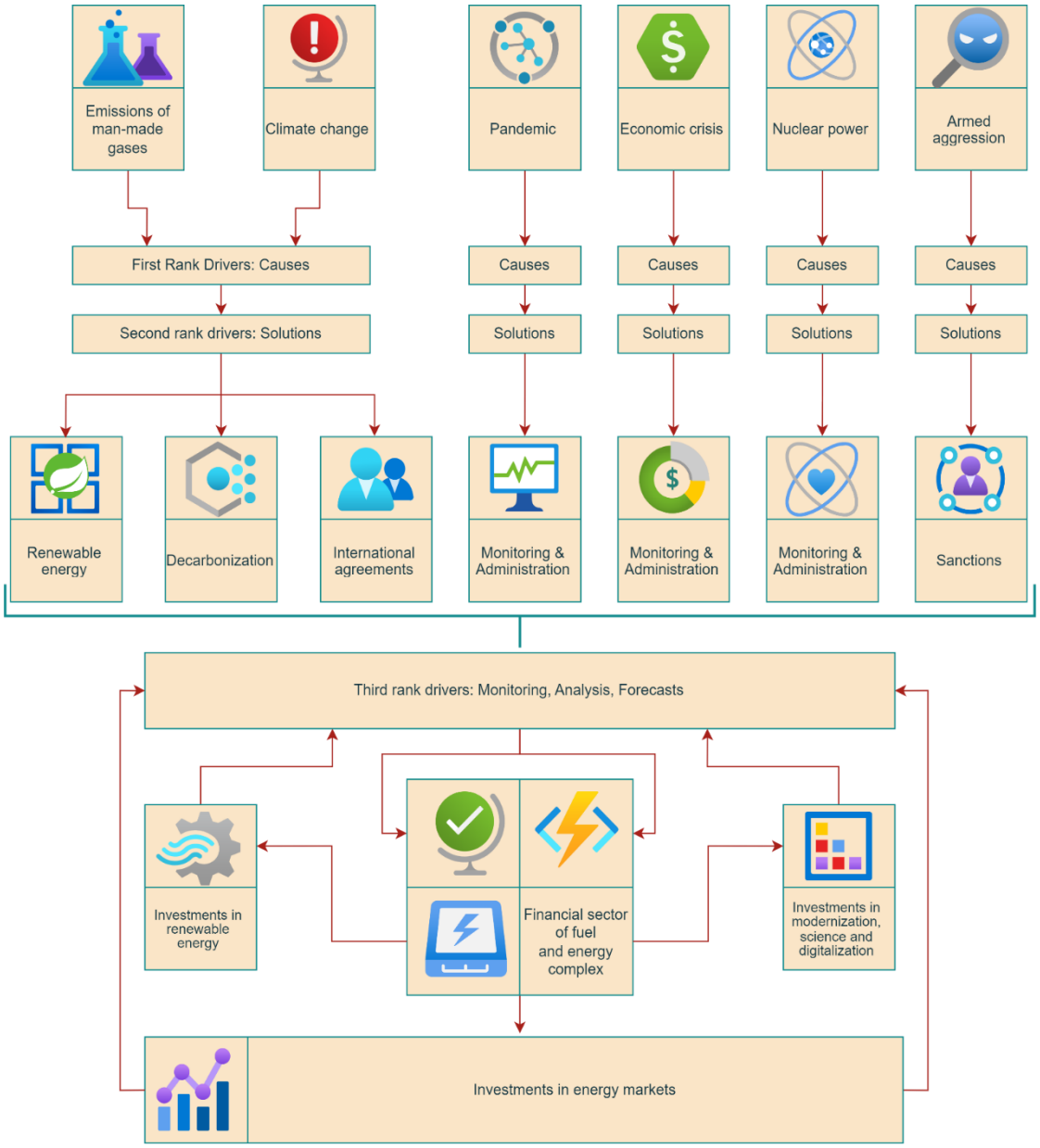

Figure 11. System of drivers for the functioning and development of the financial sector of the fuel and energy complex
Source: Created by the authors

In particular, investment analysts and forecasts, such as the IEA (Figure 12), IRENA (Figure 13), WEF (Figure 14), OECD (Figure 15), IMF (Figure 16), etc.

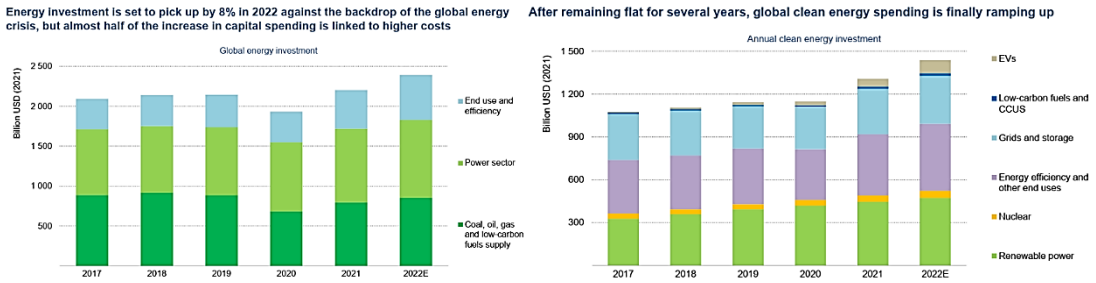

Figure 12. IEA Energy Investment Analysis
Source: IEA (2023a)

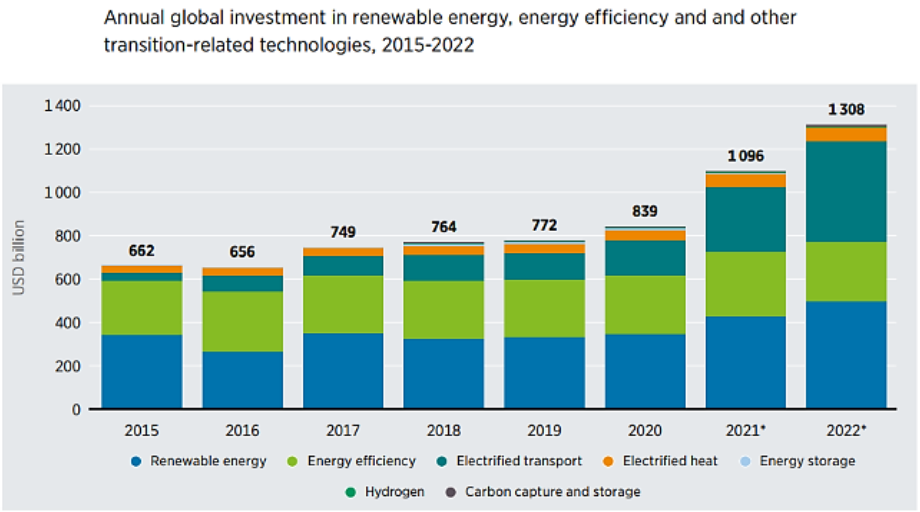

Figure 13. Energy investment analysis from IRENA
Source: IRENA (2023)

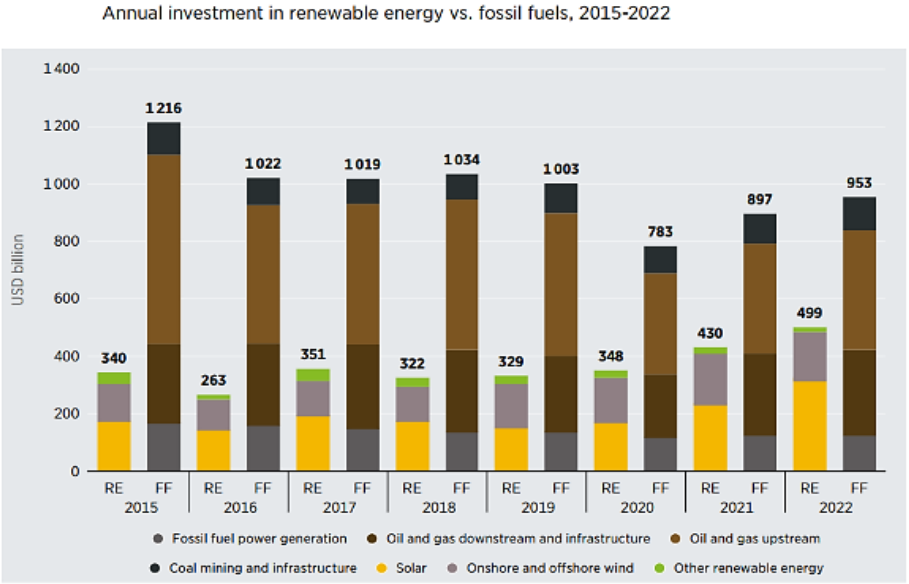

Figure 14. Energy investment analysis from WEF
Source: WEF (2023)

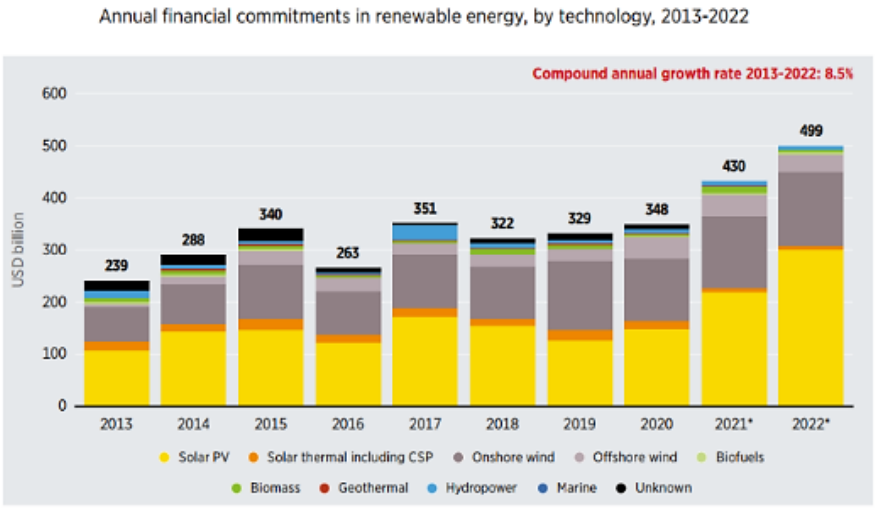

Figure 15. OECD Energy Investment Analysis
Source: OECD (2023)

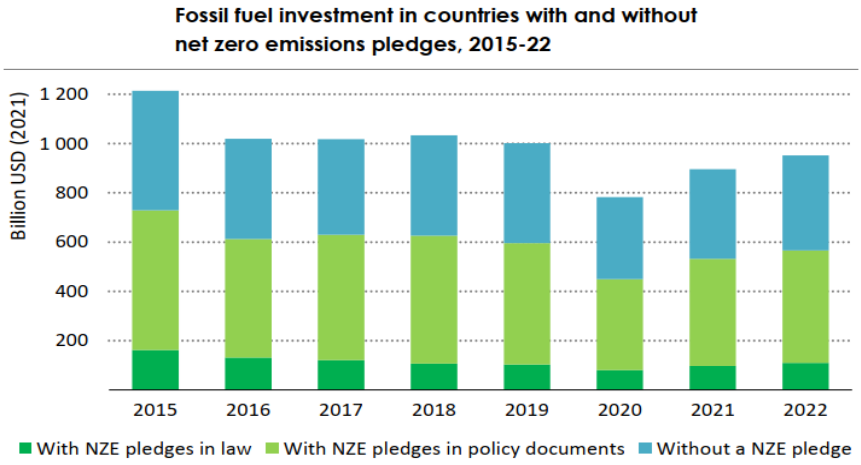

Figure 16. IMF Energy Investment Analysis
Source: IMF (2023)

Each of the expert organizations, such as IEA, IRENA, WEF, OECD, IMF, UN, WB, EBRD, EIA, EU, has its own unique approach to the analysis and assessment of the functioning and development of the financial sector of the fuel and energy complex. Each organization defines its priority aspects and investment flows, which will determine the subsequent development of the subject area and form analytical proposals regarding the short-term and long-term prospects of the financial sector and the FEC as a whole.

This creates multiple perspectives on the development of the financial sector and the FEC and provides a multifaceted approach to solving the problems associated with them. It also helps expert organizations and governments develop more effective strategies and action plans to meet global climate, energy and sustainable development goals.

Based on the data of expert opinions and forecasts let's make a rating of likely drivers of development – Table 2, Figure 17.

Table 2.
Comprehensive analysis of expert ratings of investment drivers for the development of the financial sector of the global fuel and energy complex.

	IEA	IRENA	WEF	OECD	IMF	UN	WB	EBRD	EIA	EU	Median rating	Rank	Number of times top 1	Number of times top 2	Number of times top 3	Number of times top-4	Number of times top 5	Relative investment rating
Solar photovoltaic module	1	1	2	7	6	1	9	1	2	2	1	1	4	3	0	0	0	52,0
Wind turbine (offshore and onshore)	2	2	3	8	7	2	10	2	3	3	2	1	0	4	3	0	0	35,0
Hydrogeneration	3	3	5	9	8	3	11	3	4	4	3	1	0	0	4	2	1	23,7
Nuclear power	4	20	1	1	5	20	1	6	1	5	1	1	4	0	0	1	2	44,0
Energy efficiency and other end uses	5	6	4	11	12	8	13	7	5	6	5	2	0	0	0	1	2	4,0
Digitalization of the financial sector of the fuel and energy complex	6	15	6	12	16	10	12	8	6	7	6	1	0	0	0	0	0	3,3
Development of energy networks and storage facilities	7	16	7	13	15	11	14	9	7	8	7	1	0	0	0	0	0	2,9
Closed-cycle industrial solutions	8	19	10	14	13	12	15	15	8	13	8	1	0	0	0	0	0	2,5
Low-carbon fuels and carbon capture technologies	9	17	11	15	14	9	16	10	9	9	9	1	0	0	0	0	0	2,2
Lithium-ion battery	10	7	8	16	17	13	7	11	10	10	10	4	0	0	0	0	0	0,5
Electric Transportation	11	8	9	17	18	14	8	12	11	11	11	4	0	0	0	0	0	0,5
Oil and gas production	12	9	12	2	1	16	2	16	17	1	12	6	2	2	0	0	0	3,3
Production of electricity from fossil fuels	13	12	14	6	3	17	4	17	18	12	12	4	0	0	1	1	0	1,7
Coal mining	14	11	15	4	4	18	3	18	20	14	14	5	0	0	1	2	0	1,7
Oil and Gas Refining	15	10	13	3	2	19	5	19	19	15	19	8	0	1	1	0	1	1,1
Reduced natural gas terminals	16	18	16	5	11	15	6	20	12	16	16	6	0	0	0	0	1	0,4
Geothermal energy	17	4	17	10	9	4	17	5	13	17	17	7	0	0	0	2	1	0,9
Bioenergy and Green Gas	18	5	19	18	10	5	18	4	14	18	18	6	0	0	0	1	2	0,9
Other natural solutions	19	13	20	20	19	6	19	13	15	20	19	5	0	0	0	0	0	0,2
Solid and liquid waste management	20	14	18	19	20	7	20	14	16	19	20	8	0	0	0	0	0	0,1

Source: Created by the author based on expert data

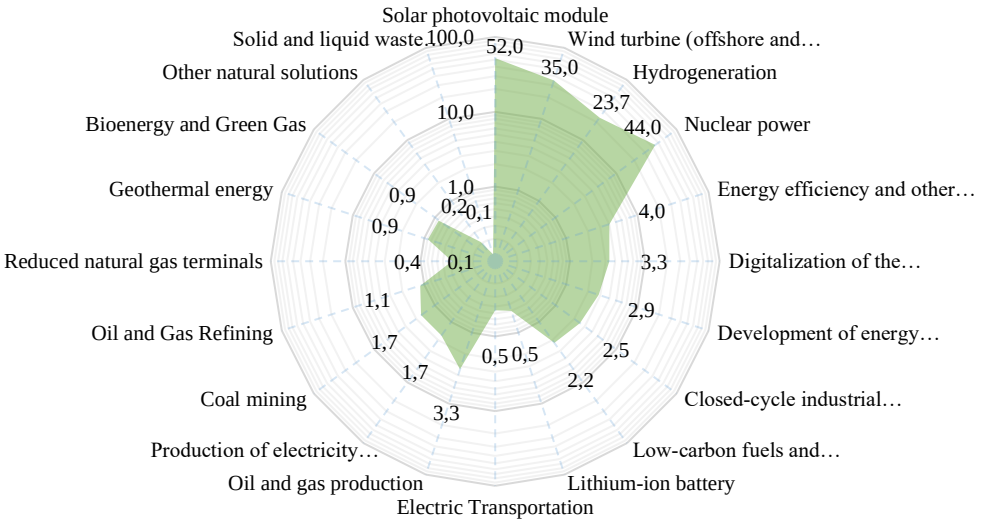

Figure 17. Determination of investment drivers of the global FEC financial sector development by the relative expert rating parameter
Source: Created by the author based on expert data

Based on the analysis of expert ratings and the formation of a median relative rating (Table 2, Figure 17), the correlation with the pre-established system of drivers for the functioning and development of the financial sector of the fuel and energy complex has been established (Figure 12). According to the results presented (Table 2, Figure 17), it was found that the surveyed expert environment highlights renewable and nuclear energy as a leader of investment attractiveness, indicating a gradual departure of the global community from the fossil hydrocarbon energy source to a more environmentally friendly and sustainable energy supply. Investment trends determined as a result of the analysis of expert opinions, conclusions and forecasts directly affecting the functioning and development of the financial sector of the global FEC (Figure 12, Table 2, Figure 17), not only correlate with the views of the scientific community (regarding the prevalence of investment attractiveness for renewable energy - Laureti, Massaro, Costantiello & Leogrande, 2023; Kumar et al., 2023; Li et al, 2023; and regarding the significant potential and impact on the FEC of the future of nuclear power - Golgovici et al., 2023; Rehm, 2023; Bistline et al., 2023), but also share a tendency to bias with the projections of leading international energy organizations. Figure 18.

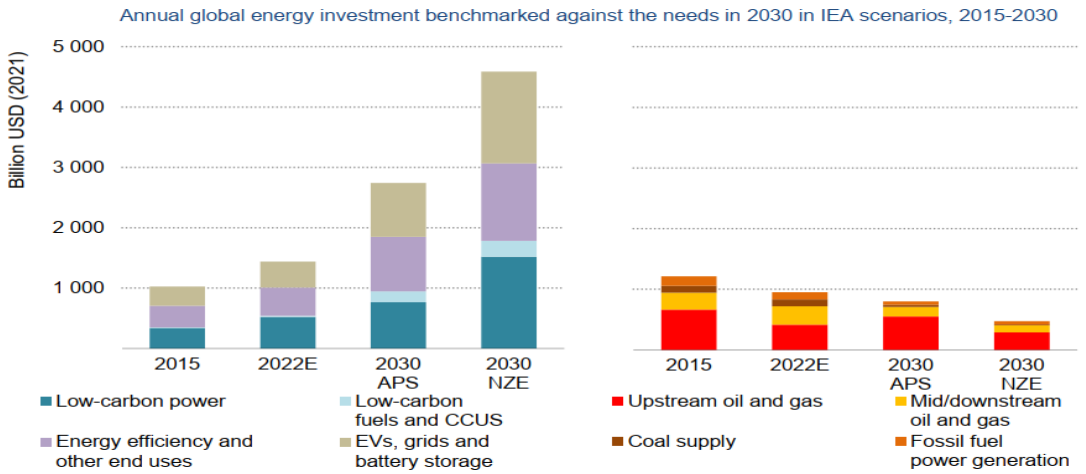

Figure 18. Analytical forecast regarding the reduction of fossil fuels in the investment balance of the financial sector of the FEC until 2050
Source: *IEA (2023b)*

However, a comprehensive analysis (Figure 12, Table 2, Figure 18) allows us to draw specialized conclusions:

1. There is a clustering of investment drivers of the functioning and development of the financial sector of the global FEC, in particular, it is possible to identify the following clusters (Table 2, Figure 18) (Table 3):

a. Efficient renewable energy (rank 1).
b. Nuclear power (rank 1).
c. Modernization of classical energy (rank 1, 2).
d. Decarbonization of classical energy (rank 1, 2).
e. Modernization of energy use (rank 4).
f. Fossil energy sources (rank 5 - 8).
g. Low-efficiency renewable energy and biotechnology (rank 7, 8).
h. Cycle of full use of resources and materials (rank 8).

2. There is a chronometric divergence of the highlighted cluster groups with a gradual withdrawal of the fossil sources cluster and a large development of the renewable and nuclear energy cluster (Figure 19).

Table 3.
Clustering of investment drivers for the functioning and development of the financial sector of the global FEC.

Cluster	Composition of the cluster	Median rating	Rank
a. Efficient renewable energy	Solar photovoltaic module	1	1
	Wind turbine (offshore and onshore)	2	1
	Hydrogeneration	3	1
b. Nuclear power	Nuclear power	1	1
c. Modernization of classical energy	Energy efficiency and other end uses	5	2
	Digitalization of the financial sector of the fuel and energy complex	6	1
	Development of energy networks and storage facilities	7	1
	Closed-cycle industrial solutions	8	1
d. Decarbonization of classical energy	Low-carbon fuels and carbon capture technologies	9	1
e. Modernization of energy use	Lithium-ion battery	10	4
	Electric Transportation	11	4
f. Fossil energy sources	Oil and gas production	12	6
	Production of electricity from fossil fuels	12	4
	Coal mining	14	5
	Oil and Gas Refining	19	8
	Reduced natural gas terminals	16	6
g. Low-efficiency renewable energy and biotechnology	Geothermal energy	17	7
	Bioenergy and Green Gas	18	6
	Other natural solutions	19	5
h. Cycle of full use of resources and materials	Solid and liquid waste management	20	8

Source: Created by the authors

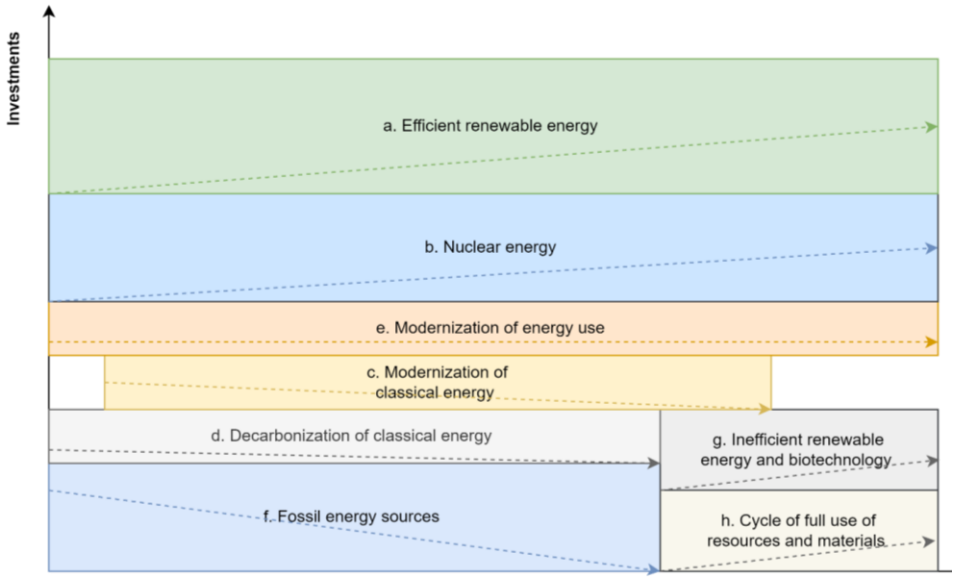

Figure 19. Chronometric divergence of selected cluster groups with the gradual withdrawal of the fossil sources cluster and the large development of the renewable and nuclear energy cluster.
Source: Created by the authors

Conclusions

Thus, an analysis of expert opinions and forecasts by leading international organizations shows that in the coming years the financial sector of the global fuel and energy complex will continue the transition to investing in renewable energy and reducing dependence on fossil sources. However, the global community remains divided about the future of nuclear power, which could become one of the alternative solutions to reduce the carbon footprint. Overall, an analysis of expert opinions and forecasts demonstrates that the financial sector of the global FEC will continue to adapt to changing environmental requirements and risk factors, given the trend toward sustainability and responsibility in investment decisions. Despite the general trend of increasing investment in renewable energy, there are regional differences in the attractiveness of different clusters. For example, in some regions of the world, such as the Middle East, there is still a high demand for fossil energy, while in other regions, such as Europe, there is a shift to renewables.

In addition, it can be noted that the effectiveness of investment in different clusters can vary significantly depending on a number of factors, such as technological progress, regulatory measures, political stability, and other factors. Therefore, continuous monitoring and analysis of the market is necessary to make informed decisions about investing in different clusters.
The benefits of using the results of the clustering of investment drivers of the functioning and development of the financial sector of the global FEC can be different.

First, this clustering can be used for decision-making in the field of investment in the FEC, allowing the selection of the most promising areas of development and reducing the risks of investing in less promising sectors.

Secondly, the results of clustering can be used to determine the priority areas of national FEC development and the formation of strategies and programs for the development of this industry.

Third, clustering can be used as a tool to identify trends and prospects in the global energy industry and shape international cooperation strategies.

Finally, the results of this clustering can be used to more accurately predict the future development of the FEC and financial sector, which can help improve the quality of decision-making and reduce risks for businesses and investors. For further study and analysis of the functioning and development of the financial sector of the global FEC, it is possible to use more diverse research methods, such as expert evaluations, multiple regression analyses, cluster analysis and other statistical methods.

It is also possible to consider various aspects that may affect the functioning and development of the financial sector of the fuel and energy complex, such as political, economic and social factors. It is important to take into account the interdisciplinary nature of the subject of research

and the involvement of specialists in different fields of knowledge for a more complete analysis.

In addition, it should be considered that the global FEC and financial sector are dynamic and constantly changing areas, so it is necessary to regularly update and revise the results and forecasts obtained in order to monitor changes and adapt to them. This can help to form more accurate and timely analytical recommendations and suggestions for investors and participants in the financial sector of the FEC.

Bibliographic references

Abbas, J., Wang, L., Belgacem, S. B., Pawar, P. S., Najam, H., & Abbas, J. (2023). Investment in renewable energy and electricity output: The role of green finance, environmental tax, and geopolitical risk: Empirical evidence from China. Energy, 269, 126683. https://doi.org/10.1016/j.energy.2023.126683

Achuo, E., Kakeu, P., & Asongu, S. (2023). Financial development, human capital and energy transition: A global comparative analysis. European Xtramile Centre of African Studies WP/23/005. http://dx.doi.org/10.2139/ssrn.4316016

Adebayo, T. S., Kartal, M. T., Ağa, M., & Al-Faryan, M. A. S. (2023). Role of country risks and renewable energy consumption on environmental quality: Evidence from MINT countries. Journal of Environmental Management, 327, 116884. https://doi.org/10.1016/j.jenvman.2022.116884

Alam, M. M., Aktar, M. A., Idris, N. D. M., & Al-Amin, A. Q. (2023). World Energy Economics and Geopolitics amid COVID-19 and Post-COVID-19 Policy Direction: World Energy Economics and Geopolitics amid COVID-19. World Development Sustainability, 100048. https://doi.org/10.1016/j.wds.2023.100048

Ali, K., Jianguo, D., & Kirikkaleli, D. (2023). How do energy resources and financial development cause environmental sustainability? Energy Reports, 9, 4036-4048. https://doi.org/10.1016/j.egyr.2023.03.040

Al-Shetwi, A. Q. (2022). Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges. Science of The Total Environment, 153645. https://doi.org/10.1016/j.scitotenv.2022.153645

Anu Singh, A. K., Raza, S. A., Nakonieczny, J., & Shahzad, U. (2023). Role of financial inclusion, green innovation, and energy efficiency for environmental performance? Evidence from developed and emerging economies in the lens of sustainable development. Structural Change and Economic Dynamics, 64, 213-224. doi: https://doi.org/10.1016/j.strueco.2022.12.008

Azam, M., Hunjra, A. I., & Taskin, D. (2023). Macroeconomic-Financial Policies and Climate Change Nexus: Theory & Practices. In Crises and Uncertainty in the Economy (pp. 51-69). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-19-3296-0_3

Ballal, V., Cavalett, O., Cherubini, F., & Watanabe, M. D. B. (2023). Climate change impacts of e-fuels for aviation in Europe under present-day conditions and future policy scenarios. Fuel, 338, 127316. https://doi.org/10.1016/j.fuel.2022.127316

Berkeley Earth. (2021, October 16). Environmental science, data, and analysis of the highest quality Independent, non-governmental, and open-source. https://berkeleyearth.org/

Bhattacharya, R., & Bose, D. (2023). Energy and water: COVID-19 impacts and implications for interconnected sustainable development goals. Environmental Progress & Sustainable Energy, 42(1), e14018. https://doi.org/10.1002/ep.14018

Bistline, J., Bragg-Sitton, S., Cole, W., Dixon, B., Eschmann, E., Ho, J., … Sowder, A. (2023). Modeling nuclear energy's future role in decarbonized energy systems. IScience, 26(2), 105952. https://doi.org/10.1016/j.isci.2023.105952

Borio, C., Claessens, S., & Tarashev, N. (2023, April). Finance and climate change risk: Managing expectations. In CESifo Forum, 24(1), 5-7. Institute for Economic Research (Ifo). https://www.proquest.com/docview/2770726749?pq-origsite=gscholar&fromopenview=true

Caglar, A. E. (2023). Can nuclear energy technology budgets pave the way for a transition toward low-carbon economy: insights from the United Kingdom. Sustainable Development, 31(1), 198-210. https://doi.org/10.1002/sd.2383

Chen, Y., Jiang, J., Wang, L., & Wang, R. (2023). Impact assessment of energy sanctions in geo-conflict: Russian–Ukrainian

war. Energy Reports, 9, 3082-3095. https://doi.org/10.1016/j.egyr.2023.01.124

Cheng, F., Luo, H., Jenkins, J. D., & Larson, E. D. (2023). The value of low-and negative-carbon fuels in the transition to net-zero emission economies: Lifecycle greenhouse gas emissions and cost assessments across multiple fuel types. Applied Energy, 331, 120388. https://doi.org/10.1016/j.apenergy.2022.120388

Chishti, M. Z., Sinha, A., Zaman, U., & Shahzad, U. (2023). Exploring the dynamic connectedness among energy transition and its drivers: Understanding the moderating role of global geopolitical risk. Energy Economics, 119(106570), 106570. https://doi.org/10.1016/j.eneco.2023.106570

Ciola, E., Turco, E., Gurgone, A., Bazzana, D., Vergalli, S., & Menoncin, F. (2023). Enter the MATRIX model:a Multi-Agent model for Transition Risks with application to energy shocks. Journal of Economic Dynamics & Control, 146(104589), 104589. https://doi.org/10.1016/j.jedc.2022.104589

Colenbrander, S., Vaze, P., Vikas, C., Ayer, S., Kumar, N., Vikas, N., & Burge, L. (2023). Low-carbon transition risks for India's financial system. Global Environmental Change: Human and Policy Dimensions, 78(102634), 102634. https://doi.org/10.1016/j.gloenvcha.2022.102634

Colgan, J. D., & Hinthorn, M. (2023). International energy politics in an age of climate change. Annual Review of Political Science (Palo Alto, Calif.), 26(1). https://doi.org/10.1146/annurev-polisci-051421-124241

Dong, C., Wu, H., Zhou, J., Lin, H., & Chang, L. (2023). Role of renewable energy investment and geopolitical risk in green finance development: Empirical evidence from BRICS countries. Renewable Energy, 207, 234-241. https://doi.org/10.1016/j.renene.2023.02.115

Doytch, N., Elheddad, M., & Hammoudeh, S. (2023). The financial Kuznets curve of energy consumption: Global evidence. Energy Policy, 177(113498), 113498. https://doi.org/10.1016/j.enpol.2023.113498

Golgovici, F., Tudose, A. E., Diniasi, D., Nartita, R., Fulger, M., & Demetrescu, I. (2023). Aspects of applied chemistry related to future goals of safety and efficiency in materials development for nuclear energy. Molecules, 28(2), 874. https://doi.org/10.3390/molecules28020874

Gollakota, A. R., & Shu, C. M. (2023). COVID-19 and energy sector: Unique opportunity for switching to clean energy. Gondwana Research, 114, 93-116. https://doi.org/10.1016/j.gr.2022.01.014

Groves, D. I., Santosh, M., & Zhang, L. (2023). Net zero climate remediations and potential terminal depletion of global critical metal resources: A synoptic geological perspective. Geosystems and Geoenvironment, 2(1), 100136. https://doi.org/10.1016/j.geogeo.2022.100136

Ha, L. T. (2023). A wavelet analysis of dynamic connectedness between geopolitical risk and renewable energy volatility during the COVID-19 pandemic and Ukraine-Russia conflicts. Environmental Science and Pollution Research International. https://doi.org/10.1007/s11356-023-26033-1

Hassan, S. T., Wang, P., Khan, I., & Zhu, B. (2023). The impact of economic complexity, technological advances, and nuclear energy consumption on the ecological footprint of the USA: Towards circular economy initiatives. Gondwana Research, 113, 237-246. https://doi.org/10.1016/j.gr.2022.11.001

He, X., Khan, S., Ozturk, I., & Murshed, M. (2023). The role of renewable energy investment in tackling climate change concerns: Environmental policies for achieving SDG-13. Sustainable Development. https://doi.org/10.1002/sd.2491

Hossain, M. R., Singh, S., Sharma, G. D., Apostu, S.-A., & Bansal, P. (2023). Overcoming the shock of energy depletion for energy policy? Tracing the missing link between energy depletion, renewable energy development and decarbonization in the USA. Energy Policy, 174(113469), 113469. https://doi.org/10.1016/j.enpol.2023.113469

IEA. (2023a). World Energy Investment 2022. Paris, France: International Energy Agency. Retrieved from https://www.iea.org/

IEA. (2023b). Net Zero by 2050 A Roadmap for the Global Energy Sector. Paris, France: International Energy Agency. Retrieved from https://www.iea.org/

IMF. (2023). Fossil fuel investment in countries with and without net zero emissions pledges, 2015-22. Washington, D.C., U.S.: International Monetary Fund. Retrieved from https://www.imf.org/

IRENA. (2023). Global Landscape of Renewable Energy Finance 2022. Masdar City, United Arab Emirates: International Renewable

Energy Agency. Retrieved from https://www.irena.org/

Jalgasovna, A. G., Abduvakhabovna, N. S., & Ramizitdinovna, T. B. (2023). Analysis and assessment of the sustainable development of fuel and energy complex enterprises in the conditions of the formation of the digital economy. Journal of Pharmaceutical Negative Results, 6587-6602. Doi: 10.47750/pnr.2022.13.S07.800

Jia, Q. (2023). The impact of green finance on the level of decarbonization of the economies: An analysis of the United States', China's, and Russia's current agenda. Business Strategy and the Environment, 32(1), 110-119. https://doi.org/10.1002/bse.3120

Kerimkulova, D., Nazekova, M., Sovetbekova, A., Muravskyi, O., & Krasovska, G. (2021). Assessment of the impact of bank lending on business entities' performance using structural equation modeling. Banks and Bank Systems, 16(2), 68-77. https://doi.org/10.21511/bbs.16(2).2021.07

Khan, I., Zakari, A., Dagar, V., & Singh, S. (2022). World energy trilemma and transformative energy developments as determinants of economic growth amid environmental sustainability. Energy Economics, 108(105884), 105884. https://doi.org/10.1016/j.eneco.2022.105884

Khutorna, M., Rudenko, M., Nemish, Yu., Kulinich, T., & Hasii, O. (2021). The development of diagnostic tools for assessing the level of financial corporations' stability by cascade approach. Financial and credit activity: problems of theory and practice, 4(39), 109-120. https://doi.org/10.18371/fcaptp.v4i39.241299

Kolodii, S., Gariaga, L., Rudenko, M., & Kolodii, S. (2019). Econometric analysis of indicators of development of financial and real economic sectors. Financial and credit activity: problems of theory and practice. 4(31), 279-290. https://doi.org/10.18371/fcaptp.v4i31.190917

Kumar, C. M. S., Singh, S., Gupta, M. K., Nimdeo, Y. M., Raushan, R., Deorankar, A. V., … Nannaware, A. D. (2023). Solar energy: A promising renewable source for meeting energy demand in Indian agriculture applications. Sustainable Energy Technologies and Assessments, 55(102905), 102905. doi: https://doi.org/10.1016/j.seta.2022.102905

Laureti, L., Massaro, A., Costantiello, A., & Leogrande, A. (2023). The Impact of Renewable Electricity Output on Sustainability in the Context of Circular Economy: A Global Perspective. Sustainability, 15(3), 2160. https://doi.org/10.3390/su15032160

Li, X., Raorane, C. J., Xia, C., Wu, Y., Tran, T. K. N., & Khademi, T. (2023). Latest approaches on green hydrogen as a potential source of renewable energy towards sustainable energy: Spotlighting of recent innovations, challenges, and future insights. Fuel, 334, 126684. https://doi.org/10.1016/j.fuel.2022.126684

Manigandan, P., Alam, M. S., Alagirisamy, K., Pachiyappan, D., Murshed, M., & Mahmood, H. (2023). Realizing the Sustainable Development Goals through technological innovation: juxtaposing the economic and environmental effects of financial development and energy use. Environmental Science and Pollution Research International, 30(3), 8239-8256. doi: https://doi.org/10.1007/s11356-022-22692-8

Marhasova, V., Kovalenko, Y., Bereslavska, O., Muravskyi, O., Fedyshyn, M., & Kolesnik, O. (2020). Instruments of monetary-and-credit policy in terms of economic instability. International Journal of Management, 11(5), 43-53. https://acortar.link/JZRnxm

Naumann-Woleske, K. (2023). Agent-based Integrated Assessment Models: Alternative Foundations to the Environment-Energy-Economics Nexus. arXiv preprint. https://doi.org/10.48550/arXiv.2301.08135

Nibedita, B., & Irfan, M. (2023). The Dynamic Nexus Among Energy Diversification and Carbon Emissions in the E7 Economies: Investigating the Moderating Role of Financial Development. Emerging Markets Finance and Trade, 1-14. https://doi.org/10.1080/1540496X.2022.2161817

Niyazbekova, S.U.,Ivanova, O.S., Suleimenova, B., Yerzhanova, S.K., & Berstembayeva, R.K. (2021). Oil and Gas Investment Opportunities for Companies in Modern Conditions. Studies in Systems, Decision and Control, 314, 669-676. https://acortar.link/zaKJTp

Nurpeisova, A., Mauina, G., Niyazbekova, S., Jumagaliyeva, A., Zholmukhanova, A., Tyurina, Y. G., Murtuzalieva, S., & Maisigova, L. A. (2020). Impact of R&D expenditures on the country's innovative potential: a case study. Journal of Entrepreneurship and Sustainability Issues, 8(2), 682-697. https://doi.org/10.9770/jesi.2020.8.2(41)

OECD. (2023). Annual financial commitments in renewable energy, by technology, 2013-2022. Paris, France: Organisation for Economic Co-operation and Development. Retrieved from https://www.oecd.org/

Our World in Data. (2023a). Energy Production and Consumption. Oxford, England: Global Change Data Lab. Retrieved from https://ourworldindata.org/

Our World in Data. (2023b). CO2 emissions. Oxford, England: Global Change Data Lab. Retrieved from https://ourworldindata.org/

Polishchuk, Y., Kornyliuk, A., Lopashchuk, I., & Pinchuk, A. (2020). SMEs debt financing in the EU: on the eve of the coronacrisis. Banks and Bank Systems, 15(3), 81-94. doi: https://doi.org/10.21511/bbs.15(3).2020.08

Prokopenko, O.V., & Shkola, V.Y. (2012). Controlling of the ecological and economic enterprise security on the bases of ecomarketing. Marketing and Management of Innovation, 4, pp. 337-346.

Rehm, T. E. (2023). Advanced nuclear energy: the safest and most renewable clean energy. Current Opinion in Chemical Engineering, 39(100878), 100878. https://doi.org/10.1016/j.coche.2022.100878

Rode, A., Carleton, T., Delgado, M., Greenstone, M., Houser, T., Hsiang, S., … Yuan, J. (2021). Estimating a social cost of carbon for global energy consumption. Nature, 598(7880), 308-314. doi: https://doi.org/10.1038/s41586-021-03883-8

Sadiq, M., Shinwari, R., Wen, F., Usman, M., Hassan, S. T., & Taghizadeh-Hesary, F. (2023). Do globalization and nuclear energy intensify the environmental costs in top nuclear energy-consuming countries? Progress in Nuclear Energy, 156(104533), 104533. https://doi.org/10.1016/j.pnucene.2022.104533

Sayed, E. T., Olabi, A. G., Alami, A. H., Radwan, A., Mdallal, A., Rezk, A., & Abdelkareem, M. A. (2023). Renewable energy and energy storage systems. Energies, 16(3), 1415. https://doi.org/10.3390/en16031415

Shkola, V., Prokopenko, O., Stoyka, A., Nersesov, V., & Sapiński, A. (2021). Green Project Assessment within the Advanced Innovative Development Concept. Estudios de Economia Aplicada, 39(5). https://doi.org/10.25115/eea.v39i5.5135

Shpak, N., Ohinok, S., Kulyniak, I., Sroka, W., Fedun, Y., Ginevičius, R., & Cygler, J. (2022). CO2 emissions and macroeconomic indicators: Analysis of the most polluted regions in the world. Energies, 15(8), 2928. https://doi.org/10.3390/en15082928

Siddik, A. B., Khan, S., Khan, U., Yong, L., & Murshed, M. (2023). The role of renewable energy finance in achieving low-carbon growth: contextual evidence from leading renewable energy-investing countries. Energy (Oxford, England), 270(126864), 126864. https://doi.org/10.1016/j.energy.2023.126864

Simionescu, M. (2023). The renewable and nuclear energy-economic growth nexus in the context of quality of governance. Progress in Nuclear Energy, 157(104590), 104590. https://doi.org/10.1016/j.pnucene.2023.104590

Sotnyk, I., Kurbatova, T., Kubatko, O., Prokopenko, O., Prause, G., Kovalenko, Y., … & Pysmenna, U. (2021). Energy security assessment of emerging economies under global and local challenges. Energies, 14(18), 5860. https://doi.org/10.3390/en14185860

Tulchynska, S., Popelo, O., Marhasova, V., Nusinova, O., & Zhygalkevych, Z. (2021). Monitoring of the ecological condition of regional economic systems in the context of sustainable development. Journal of Environmental Management and Tourism, 12(5), 1220. https://doi.org/10.14505//jemt.v12.5(53).06

Wang, Z., Li, S., Jin, Z., Li, Z., Liu, Q., & Zhang, K. (2023). Oil and gas pathway to net-zero: Review and outlook. Energy Strategy Reviews, 45(101048), 101048. https://doi.org/10.1016/j.esr.2022.101048

WEF. (2020). COVID-19: What you need to know about the coronavirus pandemic on 14 September. Cologny, Switzerland: World Economic Forum. Retrieved from https://acortar.link/7ptCxW

WEF. (2023). Annual investment in renewable energy vs. fossil fuels, 2015-2022. Cologny, Switzerland: World Economic Forum. Retrieved from https://www.weforum.org/

Xu, H.-C., Wang, Z.-Y., Jawadi, F., & Zhou, W.-X. (2023). Reconstruction of international energy trade networks with given marginal data: A comparative analysis. Chaos, Solitons, and Fractals, 167(113031), 113031. https://doi.org/10.1016/j.chaos.2022.113031

Zioło, M. (2023). Environmental risk as a challenge for the banking sector. In Environmental Risk Modelling in Banking (pp. 5-22). Routledge. https://doi.org/10.4324/9781003310099