Foresight of the Energy Transition Within the Framework of the Climate Agenda and Conditions of Geopolitical Turbulence

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Abstract: Currently, the world community is facing the acute problem of climate change, the consequences of which have a significant impact on the environment, food security, life and health of people around the world. Both environmental and social spheres are under threat. Greenhouse gas emissions emitted as a result of anthropogenic activities are peculiar catalysts of this process. The study of climate change problems and the development of measures aimed at the formation of energy security is on the agenda of many leading companies in the world. This paper analyzes the forecasts of energy sector development scenarios from IRENA World energy transitions-2022 and E.ON Forecast Digest Zeroing in on the Energy Transition-2022 in the prism of the climate agenda, as well as non-financial disclosure reports of a number of major energy companies, such as ExxonMobil, BP, Shell. In addition, the authors provide their own alternative development forecast, based on the current geopolitical situation and life-cycle analysis of renewable energy production, related to opacity, carbon footprint and environmental impact produced.

1 INTRODUCTION

The serious political crisis we have been witnessing for several years has led to significant changes in geopolitical interactions in the energy sector, creating a real threat to energy security by disrupting previously established supplies of traditional energy resources. This situation has emphasized the heavy dependence of many countries on these resources, especially in the context of the global drive to reduce carbon emissions and combat climate change. In response to these challenges, the global community is actively seeking alternative energy sources and strategies to ensure a sustainable and secure energy future.

Russian oil and gas supplies to the European Union have been suspended indefinitely, which has become a catalyst for rethinking energy policy and accelerating the transition to low-carbon energy. This decision has triggered the need for new comprehensive and sustainable infrastructure investment plans to meet climate targets by 2030. In this context, renewable energy sources such as solar, wind, hydro and green hydrogen are of particular importance, offering an alternative to conventional energy sources and helping to reduce dependence on fossil fuels.

Thus, the current geopolitical situation and related energy challenges actualize the issues of sustainable energy development, search for new energy sources and rethinking traditional approaches to energy security and environmental sustainability.

2 MATERIALS AND METHODS

Purpose of the study – analyze the forecast scenarios of the energy sector development in the context of the

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climate agenda and annual non-financial reports of major oil and gas companies in order to form an alternative forecast taking into account the current geopolitical and energy turbulence.

The research uses data from many information sources that are listed in the list of references, general scientific empirical and theoretical methods, methods of comparative analysis.

3 RESULTS

Russian oil and gas supplies to the European Union have been suspended indefinitely. European leaders interpret the current circumstances as a new impetus for the development of low-carbon energy, as well as for the development of new comprehensive and sustainable infrastructure investment plans that will help the world meet climate goals by 2030. Among the renewable energy sources that can serve as substitutes for conventional energy sources are solar, wind and hydropower. Also, one such source is green hydrogen, the production of which is planned to be increased by EU countries. The lower cost of oil and gas makes hydrogen more competitive.

Thus, the German company Energiewende sets ambitious goals, assigning to wind farms and photovoltaics the decarbonization of 85% of the electricity supply sector by 2050. It is expected that their share will reach 60% of the total energy volume. At the same time, the company plans to completely exclude nuclear energy. The above-mentioned examples illustrate the formation of a sustainable orientation of energy giants towards the goals of achieving climate goals, including achieving carbon neutrality.

However, according to Reuters, as of March 29, 2023, 27 countries of the NATO bloc continue to import Russian energy resources, putting energy stability and security above political differences. The authors of the article consider this fact as an additional factor in the possible divergence of analysts' forecasts for the development of the energy sector in the near future.

According to experts' opinions, the decarbonization policy in Russia, including the development with the prospect of introducing carbon credits, is likely to be revised, since the driver of these measures was not only the climate agenda, but also trade and export relations with the European Union, which initiated and actively supports measures on transboundary carbon regulation.

4 AN ANALYSIS OF CHANGES IN THE COST AND AVAILABILITY OF DIFFERENT TYPES OF RENEWABLE ENERGY REVEALED THE FOLLOWING RESULTS

According to Reuters, in 2022, the cost of “gray” hydrogen produced from natural gas by steam reforming in Europe increased to $ 12 per kilogram. While green hydrogen from Spain, produced using solar panels, costs only $ 4. Also, the increase in the availability of energy obtained with the help of renewable energy sources (RES) is indicated by statistics on price reduction. The cost of solar energy decreased by 85%, concentrated solar energy by 68%, onshore wind energy by 56% and offshore wind energy by 48%. Today, renewable energy is the main target area for investments by large energy and chemical companies.

In addition, it is known that various types of biofuels have already been created and are being used for land, rail, sea and air transport. Thus, the oil and gas giant BP, together with BUNGE, launched 11 biofuel plants with a capacity of 32 million tons per year.

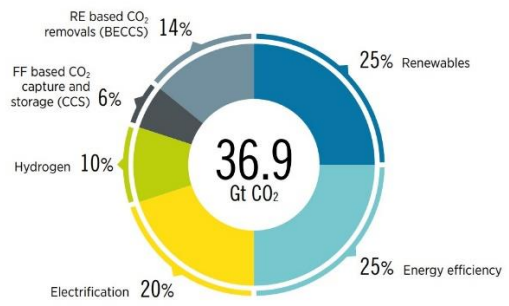

Figure 1: Reducing emissions by 2050 through six technological approaches (source IRENA Agency).

As part of the presented research review, the International Renewable Energy Agency (IRENA) formulates an optimistic forecast for achieving global carbon neutrality by 2050, assuming the integration of six advanced technological approaches detailed in Figure 1. The deployment of renewable energy sources (RES) and the improvement of energy efficiency, which account for approximately 25% of the potential for reducing carbon emissions, are highlighted as fundamental elements of this transformation. In addition, electrification of

transport and other sectors of the economy plays an important role, emphasizing the need to switch to low-carbon energy sources.

Additional coverage of this topic is provided in Figure 2, which illustrates the expected reduction in greenhouse gas emissions from the energy sector between 2018 and 2030. The data provided by the IRENA agency reflects the projected trajectory of reducing emissions as intermediate steps towards achieving carbon neutrality. These data highlight the importance of the previously mentioned technological strategies and provide a quantitative measurement of progress towards a sustainable energy future.

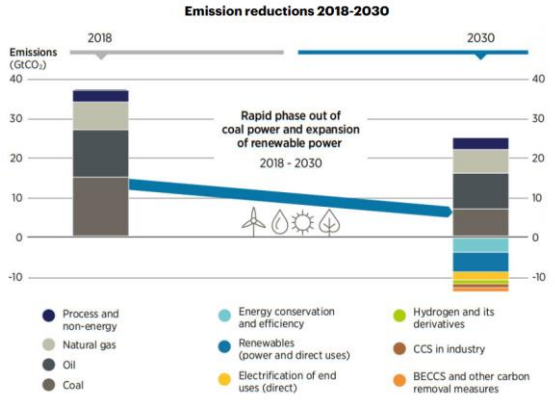

Figure 2: Expected reduction of greenhouse gas emissions from the energy sector in the period from 2018 to 2030.

The key principles of the future energy sector will be carb-free, decentralized and digitalized processes.

As the Energy transition gathers momentum, major European oil and gas companies (BP, Shell, Total, Equinor, Repsol and ENI) are adapting their businesses to meet both growing energy demand and reduce their carbon footprint over the next decade and beyond. All of them have set zero emissions targets for their businesses. Although oil and gas are expected to continue to dominate their business in 2030, there is a growing desire to increase the share of renewable energy sources (primarily wind and solar), as well as to increase natural gas production. In addition, these companies are participating in projects for the production of blue and green hydrogen, as well as increasing capacities for the use of CCUS carbon dioxide capture and utilization technologies.

The companies have formulated their strategic goals and plans for the development and use of renewable energy sources (RES) for a long period of time, focused on 2030 and 2035. Currently, these companies account for about 13 GW of installed renewable capacity (according to the February 2021 disclosure), led by Total at 7 GW (about 55%). Solar energy and onshore wind account for about 85% of the total capacity of all devices and equipment capable of producing electricity from renewable energy sources that have been installed and connected to the grid at the moment.

Major European oil and gas companies have said they will evaluate renewable energy projects with an assessment of the level of financial barriers. This means that they plan to analyze the economic viability of such projects and identify possible obstacles to their implementation that are associated with costs or financial risks. Companies also believe that they can increase the profitability of renewable energy projects by combining their operational experience, financing structures, integrated operations and portfolio rationalization.

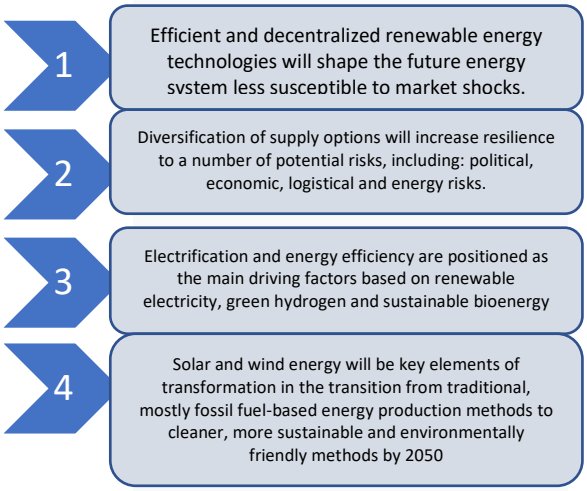

Figure 3: Key directions of global energy development in the 2050 horizon. Positive outlook (compiled by the authors).

An analysis of the annual non-financial statements of companies focused on European Union standards revealed widespread adherence to the principles of environmental, social and corporate responsibility (ESG). Companies operating within the EU or strongly associated with it integrate aspects of sustainable development into their strategic and operational activities, taking into account not only economic results, but also environmental and social impacts, as well as the quality of corporate

governance. This approach highlights the companies' commitment to comply with pan-European efforts to promote a green economy and transition to sustainable business models, which is reflected in their investment strategies and participation in projects.

So SHELL, which decided to support the Paris Agreement and its climate goals, has developed measures for its decarbonization policy, having achieved some success in this, reducing carbon emissions by 30% compared to 2016.

The company intends to become a zero-carbon energy company through significant investments in solar, wind energy, biofuels and hydrogen. SHELL has invested $2 billion in the Denmark's Nature Energy project, which produces renewable gas from household, agricultural and industrial waste. In addition, in 2022, the company invested $8.2 billion in low-carbon energy and products not related to the energy sector, of which $ 4.7 billion in biofuels, hydrogen, charging stations for electric vehicles and renewable energy sources. Commitment to a positive outlook is also confirmed by the company's construction of the Holland Hydrogen 1HYDROGEN RACE plant, which will be built in 2024 on 2,000 hectares of alluvial areas, using new environmentally friendly construction technologies. The plant will produce up to 60,000 tons of green hydrogen per year.

Table 1: Investments by leading energy companies.

Company	**Projects and Initiatives**	**The Volume of Investments**	**The Main Directions**
Rosneft	Various environmental projects	57 billion rubles (2022)	Improving environmental safety, preserving biodiversity
Lukoil	Modernization of processing facilities	More than $14 billion	Increasing the depth of processing, production of ecological class "Euro-5"
Valero Energy	Production of "green" diesel	Not specified	Development of biofuel production
Saudi Aramco	Production of green hydrogen and ammonia	Not specified	Achieving zero greenhouse gas emissions by 2050
Sinopec	Construction of a plant for the production of green hydrogen	5.7 billion yuan ($830 million)	Production of green hydrogen and oxygen

A much less positive foresight is presented by the E.ON forecasting agency, which sees the implementation of the above-mentioned principles as difficult to implement. In addition, the analysis casts doubt on the speed of energy transfer, assuming that it will last longer than planned, which will require the introduction of renewable, clean and intelligent technologies. The forecast also identifies risks related to carbon dioxide capture and burial technologies. Concerns have been expressed that the buried CO2 will come to the surface sooner or later. The storage of radioactive waste from nuclear power also raises doubts about the safety of environmental and human health impacts. The analysis of the report indicates that there is also an underestimated barrier that can significantly slow down the energy transition and the development of alternative energy in general. Alternative energy is faced with a shortage of qualified personnel. The situation is expected to worsen, as significant time and resources are needed to create and test new educational programs.

As of 2020, about 12 million people are employed in the renewable energy sector in the world, in 2030 it is expected to increase to 38 million, and in 2050 to 43 million workers. In the coming years, there will be a massive retraining of workers in the oil and gas sector, the number of jobs in which will be reduced to 6.9 million people by 2030. On the contrary, the number of employees in the hydrogen sector will increase to 2 million by 2030.

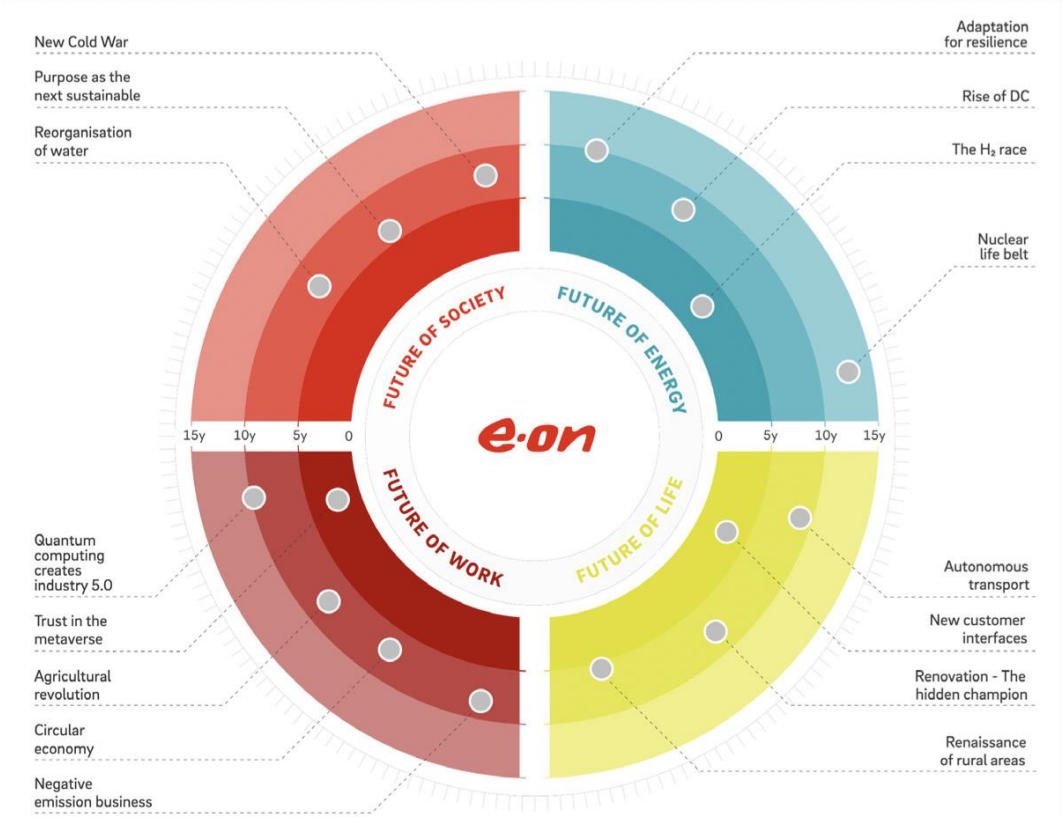

Figure 4: E.ON's energy sector development forecast for the next 15 years.

According to E.ON's forecast, a kind of hydrogen race will take place in the energy sector in the next 5 years, which will be stimulated by the introduction of carbon credits. Investments in projects for the production of green hydrogen and other sustainable energy resources, such as biogas, will help companies with a difficult-to-reduce carbon footprint achieve the desired performance. Turning to the topic of the hydrogen race, it can be argued that the introduction of carbon credits makes investments in clean technologies such as hydrogen energy more attractive. Hydrogen is considered a key element in the transition to a low-carbon economy because its use as a fuel does not lead to CO2 emissions. As a result, companies investing in the development and distribution of hydrogen technologies can potentially benefit economically from carbon credits by reducing their own greenhouse gas emissions and selling credits to those looking for ways to offset their emissions.

In the next 10 years, it is expected to strengthen the position of electrification of transport, but in 15 years, due to the insufficient effectiveness of decarbonization measures and instability of renewable energy sources, the gradual depletion of fossil resources, there will be a forced change of vector to nuclear energy.

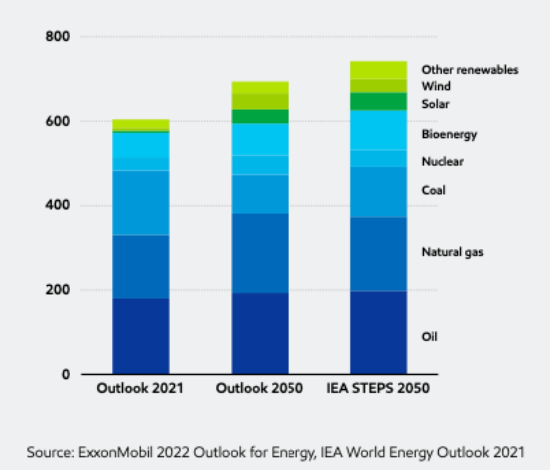

Figure 5: Comparative chart on the estimated ratio of types of energy resources by 2050 (source ExxonMobil 2022 Outlook for Energy, IEA World Energy Outlook 2021).

A comparison of 3 Outlook 2001 forecasts, Outlook 2050 IEA STEPS 2050, shows a slight discrepancy in the percentage of oil, gas, coal, nuclear energy, biofuels, solar, wind and other renewable energy sources. The main volume is occupied by traditional energy sources. There is an obvious discrepancy with the forecast of the IRENA agency.

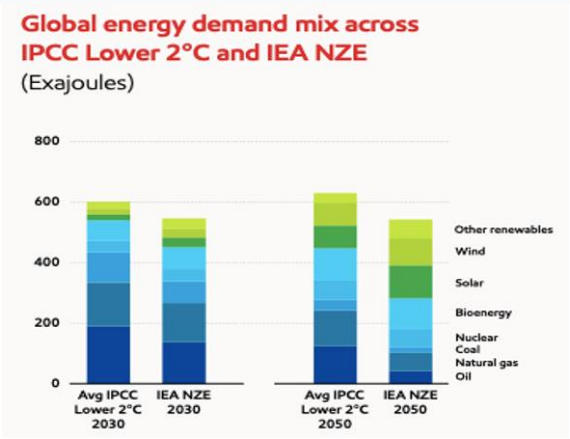

Figure 6: Comparative diagram on the estimated ratio of types of energy resources by 2030 and 2050 in the Net Zero Emission concept (source ExxonMobil analysis, IEA World Energy Outlook 2021, IPPC Sixth Assessment Report).

The diagram above (Fig. 6) presents a more extreme forecast based on the goal of limiting the temperature rise to 1.5 C. When making the forecast, we started from the final critical point for curbing global warming within 2 degrees C.

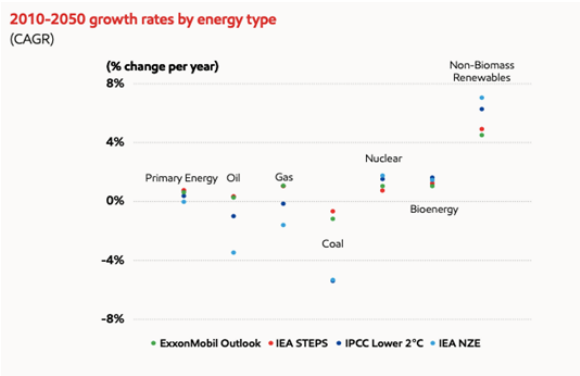

Figure 7: Comparative diagram of the estimated change in the ratio of energy resources in 2050.

Figure 7 shows the most noticeable discrepancies in the forecast from the agencies regarding the use of oil, gas and coal. The greatest coincidence, according to the agencies, concerns biofuels. Obviously, this is the absolute advantage of the NSE IEA (net zero emission).

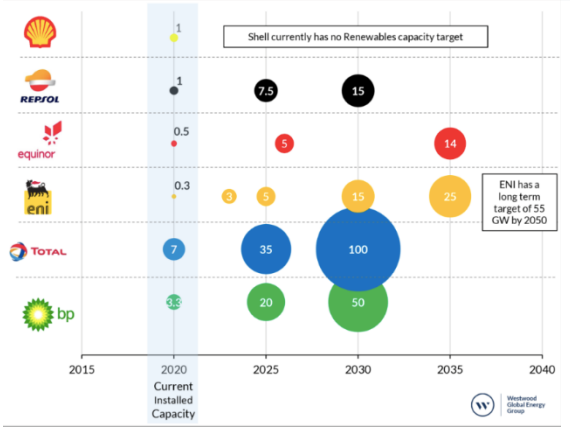

Figure 8: Long-term goals of oil and gas corporations for the total increase in renewable energy capacity (source Westwood Global Energy Group).

Figure 8 shows how different the goals for capacity building in renewable energy projects are. Thus, Shell has not yet confirmed its measurable goals, while TOTAL has set a goal to increase its renewable energy capacity to a significant level by 2030. This reflects the different approaches to the strategy of sustainable development in the energy sector. While Shell has not yet decided on specific goals, TOTAL is actively investing in solar and wind energy projects, aiming to become one of the leaders in the field of green energy. This difference in strategies may be due to various factors, including corporate policies, market conditions, and regulatory requirements in different countries.

The conducted study of forecast scenarios for the development of the global energy system presented by international rating agencies allows us to conclude that in the next 5 years, hydrogen energy will develop rapidly. The key challenges are related not only to the high cost of producing green hydrogen, the high cost of carbon dioxide capture and burial technologies in the production of blue hydrogen (Dawood, 2020), the search for new ways to commercialize large amounts of solid carbon as a by-product in the production of turquoise hydrogen, the lack of infrastructure, but also with recent research presented by Bloomberg in 2022, indicating that the influence of inevitable hydrogen leaks in 20 years will lead to an even greater rate of temperature increase and deterioration of climatic indicators, than emissions from the combustion of oil, gas and coal.

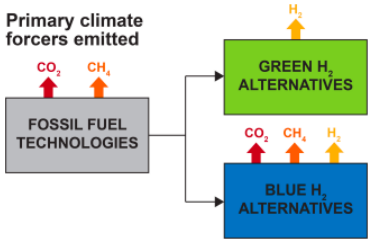

Figure 9: Comparison of emissions from traditional fuels and hydrogen (Dawood, 2020).

Figure 9 clearly shows that the production and use of blue and green hydrogen, which are regarded as the main methods for achieving decarbonization of the energy and transport sectors, along with traditional energy sources, are accompanied by the emission of gases that negatively affect the rate of global warming.

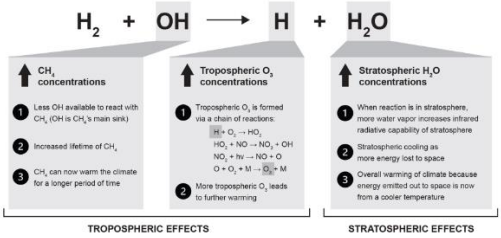

Figure 10: The effect of hydrogen leaks on the heating of the troposphere and stratosphere (Dawood, 2020).

Figure 10 shows the chains of chemical reactions triggered by hydrogen leaks. As can be seen, the effect is associated with the interaction of hydrogen with other components of air and gases. At the same time, the warming effect occurs both in the troposphere and in the stratosphere, so hydrogen can significantly accelerate the process of global warming, which contradicts the goals of the climate agenda.

The research results (Labidine, Messaoudani, Rigas, Hamid, Hazards, 2016; Konishchev, Semenov, CHaban, Lobanova, Kashkovskij, 2019; Abdalla, Hossain, Nisfindy, Azad, Dawood, Azad, 2018) also indicate a number of unresolved difficulties and challenges associated with the use of hydrogen, including its ability to reduce the ductility and strength of metals, which entails regular and significant costs for replacing pipelines, increasing the economic inexpediency of using hydrogen.

Comparative analysis of various forecasts for the development of the energy sector from different agencies and companies

4 DISCUSSION

Based on the analysis, the authors have developed their own vision for the forecast of energy development in the world. Recent studies indicate that hydrogen is likely to be removed from its role as the main tool for decarbonizing the energy and transport sectors. It may take from 5 to 10 years until the moment of complete abandonment, since long-term projects for the development of hydrogen technologies and production have already been launched, entire hydrogen clusters are developing, including in Russia, and the hydrogen infrastructure is being built up. At the same time, hydrogen production using methane pyrolysis (turquoise hydrogen) will be the most appropriate, since despite the development of technologies for carbon dioxide capture and storage, the economic feasibility and long-term effectiveness are questionable. While many large enterprises and government institutions have already taken steps and investments to slow global warming, there is a risk that the progress made may require reassessment and adjustment due to new circumstances and research results.

The authors of the article see significant potential in the development of biofuel production, since the population is growing, and economic growth entails an increase not only in energy consumption, but also in household overconsumption in general, which affects the growth of waste volumes that can be recycled into energy.

At the same time, the authors suggest that traditional fuel sources will prevail over alternative ones in the coming decades, since the production of equipment for solar panels and wind farms requires fossil resources that are at risk of depletion. It is also important to take into account the fact that most of such equipment is currently manufactured in China, while coal is often used as an energy resource, the dirtiest type of fuel in terms of greenhouse gas emissions. The need to transport equipment and the lack of technologies for full-fledged recycling of used equipment complements the already significant carbon footprint.

5 CONCLUSION

Despite the discrepancies in the forecasts of different agencies on the distribution of the energy mix in the short and long term, all analyzed sources show unanimous support for the climate agenda and emphasize the need to continue developing and

implementing measures to curb the growth of global warming despite emerging geopolitical factors. This means that the course towards the development of low-carbon energy will be continued. Geopolitical tensions have had a significant impact on the revision of scenarios and the postponement of the implementation of projects to reduce the carbon footprint. Based on the studies reviewed in the article concerning the effect of hydrogen leaks on the rate of climate change, the place of hydrogen as a leading decarbonization tool will be taken by biofuels, including those produced from waste. The introduction of measures aimed at developing a closed-cycle economy, breaking the link between economic growth and the volume of household and electricity consumption, will also have a great impact on decarbonizing economies.

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