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STRATEGIES OF ENERGY COMPANIES IN THE CONTEXT OF A ZERO-EMISSION ECONOMY

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Purpose: The global imperative to fight climate change and the transition to a zero-emission economy has forced significant transformations in the energy sector. The aim of the article is to examine the strategies and analyze the actions taken by energy companies in order to transition to a zero-emission economy.
Design/methodology/approach: By using desk research and case study analysis, policy frameworks and industry trends, this paper offers a comprehensive overview of the different approaches used by energy companies to align their operations with environmental sustainability goals.
Findings: The results of the conducted research contribute to understanding the strategies of enterprises in the context of environmental challenges and provide valuable insights on the key role played by energy companies in shaping the applied solutions towards a sustainable future.
Practical implications: Energy companies can use the results of this research to develop and implement strategies to achieve a zero-emission economy. These studies provide guidance on best practices, technologies and business models that can be used to reduce greenhouse gas emissions and negative environmental impacts.
Social implications: The strategies used by energy companies allow the implementation of a zero-emission economy and reduce the negative impact on the environment, generate a significant social impact, such as improving the quality and living conditions, clean air, reducing energy poverty. In addition, the development of renewable energy and energy efficiency technologies can attract foreign investment and create new export opportunities for green technologies, which translates into economic growth and job creation.
Originality/value: The novelty of the research is the presentation of strategies (mainly adaptations) that allow energy companies to adapt to external requirements and enable the implementation of tasks related to renewable energy and energy efficiency. This provides the basis for the development of new technologies. Enterprises can use this research to design and implement modern solutions, such as digitization, developing more efficient photovoltaic panels, building energy storage or smart energy grids.

Keywords: energy, zero-emission, strategy, adaptations, innovations.

Category of the paper: Research paper.

1. Introduction

The urgency of addressing climate change and reducing greenhouse gas emissions has catalyzed global efforts to transition to a carbon-free economy (Dilanchiev et al., 2023). Our planet is facing major environmental challenges, including global warming, sea level rise and more frequent and intense extreme events (Borowski, 2020b; Borowski, 2022). As ecological tensions grow, so does the pressure on governments, international organizations and, above all, businesses to adopt a more sustainable approach to energy production and consumption.

As the main participants in emissions, energy companies play a key role in this transformation. Energy companies, through the supply of electricity and propulsion fuel, generate a significant share of greenhouse gas emissions. However, paradoxically, they also have the potential and the ability to transform the way we produce and consume energy. This is the starting point for this article - understanding how energy companies are responding to the challenges of climate change and how they contribute to global sustainability efforts.

The purpose of this article is to examine the strategies used by energy companies to adapt to the changing energy landscape and achieve the Sustainable Development Goals. The various approaches these companies are taking to minimize greenhouse gas emissions, increase energy efficiency and promote the use of renewable energy sources will be discussed. By analyzing case studies, assessing policy frameworks, and identifying key industry trends, this research aims to provide a comprehensive view of how energy companies fit into the drive for a sustainable future.

Therefore, in the face of impending climate challenges and the imperative for sustainable development, it is crucial to comprehend the actions taken by these companies and their impact on the future of energy and the natural environment. By exploring these issues, we are able to not only assess progress towards a more sustainable energy future, but also to draw valuable lessons about the role that energy companies play in shaping the economic future.

2. Methods

In this study, a qualitative research approach was utilized to comprehensively investigate the strategies adopted by energy companies operating in a changing energy environment and working towards achieving sustainable development goals.. The utilization of qualitative research is particularly well-suited for this study as it enables an in-depth exploration of complex phenomena such as the strategies and actions of companies in response to environmental challenges.

The first stage involves gathering data from available published materials, encompassing an extensive review of existing literature, including policy frameworks, academic articles, statistical data, and industry reports. This analysis of secondary data plays a crucial role in contextualizing the strategies of energy companies within the broader regulatory and industry landscape. It allows for a comprehensive examination of external factors influencing and shaping the strategies of these companies.

For the analysis of the research findings obtained through desk research, a content analysis method is employed. This method involves a systematic examination and categorization of textual data from published policy documents, academic literature, and industry reports. Such an approach aids in the identification of key policy frameworks, trends, and regulatory influences impacting the strategies of energy companies. Furthermore, qualitative data obtained from case studies and insights derived from secondary source research are integrated to ensure a comprehensive understanding of the strategies employed by energy companies in response to environmental challenges. The combination of these two data sources enables the triangulation of results, enhancing the validity and reliability of the research findings.

In this study, a qualitative research approach was applied within the context of a changing energy landscape and the imperative of sustainable development. The integration of diverse data sources and robust qualitative analysis techniques facilitated a comprehensive analysis of companies' responses to environmental challenges, shedding light on the role of energy companies in shaping the future of sustainable energy.

3. Literature review

This study is based on a comprehensive literature review, which is the basis for research conducted using the desk research method. Contemporary literature provides an insight into the strategies and approaches used by energy companies seeking to mitigate the negative environmental effects associated with energy production and presents innovative solutions in the field of adaptive technologies. Table 1 presents the latest research in the field of strategies and activities of energy companies.

Table 1.
Selected most important studies related to energy companies

Title of the paper	Main contents presented in the paper
Incentives and strategies for financing the renewable energy transition: A review.	The paper encourages increased investment in environmentally friendly energy. Additionally, it discusses some of the strategies required to transition from fossil fuels to renewable energy sources (Qadir et al., 2021).
Energy management strategies and multi-objective optimization of a near-zero energy community energy supply system combined with hybrid energy storage.	The article discusses energy storage, which effectively addresses the issue of inconsistent energy supply and low renewable energy penetration in nearly zero-energy communities. An energy system integrated with electrical energy storage and hydrogen storage enables seasonal energy utilization with improved overall economics (Fan, et al., 2022).
Open and collaborative innovation for the energy transition: An exploratory study.	The paper identified energy companies' strategies for innovation. An open approach to innovation varies and depends on local circumstances, underlining the importance of cooperation and international partnerships for the energy transition (Dall-Orsoletta et al., 2022).
A net-zero emissions energy system in India by 2050: An exploration.	A transformational level of electrification, improved energy efficiency and a shift towards decarbonised fuels (largely green hydrogen, decarbonised electricity and bioenergy) are among the main elements of a decarbonisation strategy that could move the energy sector towards net zero emissions (Vats, Mathur, 2022).
Digital transformation in the resource and energy sectors: A systematic review.	Digital technologies have also started to have a significant impact on the commodities and energy industries. The paper identifies the technologies that have delivered the most value in different parts of the energy sector (Maroufkhani et al., 2022).
Digitalization in Energy Production, Distribution, and Consumption: A Systematic Literature Review.	In the energy sector, the infrastructure required to achieve specific goals is based on the digitization of energy production, distribution and consumption. An important element of digitization is data mining and machine learning as well as smart grid, smart metering, smart home (Simion et al., 2023).
The impact of resources on digital transformation in energy sector companies. The role of readiness for digital transformation.	Energy companies inevitably need to undergo a digital transformation to be able to dynamically respond to changes, ensuring open, automated communication and real-time operation of the energy system (Chwiłkowska-Kubala et al., 2023).
Sustainable development policies of renewable energy and technological innovation toward climate and sustainable development goals.	The achievement of climate goals is influenced by economic development, technologies, environmental policy and energy, together with technological influences on the transition to renewable energy (Xing et al., 2023).

Source: own elaboration based on literature indicated in the table above.

From the conducted literature review, fields emerge regarding the strategies and directions pursued by energy companies to achieve greenhouse gas emission reduction and the production of cleaner, environmentally friendly energy. This in-depth exploratory process allows for an examination of various practices and innovative solutions that energy companies undertake in response to urgent environmental protection and climate change challenges.

One significant aspect evident in the research is the drive of energy companies to increase the share of renewable energy in their energy mix. This often involves investments in wind farms, solar panels, hydroelectric power plants, and other renewable energy sources. The shift towards more energy sources is crucial in the sustainable pursuit of reducing greenhouse gas emissions.

Additionally, energy companies are exploring technologies that enhance energy efficiency. This encompasses the implementation of advanced energy management systems, optimization of production processes, and distribution network enhancements to reduce energy losses and fossil fuel consumption.

Furthermore, there is a growing interest in energy storage, which enables the accumulation of surplus energy during periods of abundance (e.g., from solar or wind sources) for use during periods of scarcity. This can significantly contribute to stabilizing energy supply and increasing the utilization of renewable sources.

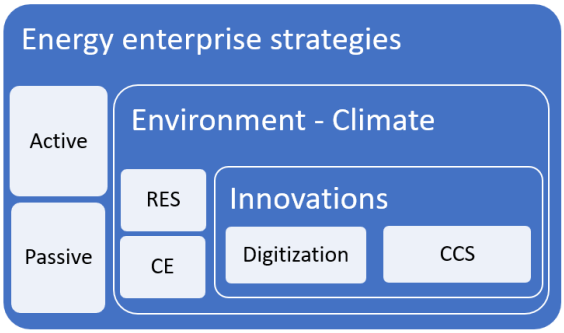
It is worth noting that energy companies are increasingly collaborating with research institutions and innovative startups to develop new technologies and solutions. This open collaboration can accelerate progress towards cleaner and more sustainable energy.

Overall, this literature review sheds light on the diverse strategies and development directions pursued by energy companies to contribute to the reduction of greenhouse gas emissions and the production of cleaner energy. These are vital in addressing pressing environmental efforts protection and climate change imperatives.

4. Results and discussion

The results of desk research reveal a multifaceted activieties within the energy sector, as companies within this industry are actively engaged in a comprehensive range of initiatives aimed at addressing the urgent issue of decarbonisation. Their endeavors extend beyond only discussions and not limited to rhetoric but embark on tangible actions as they are dedicating significant resources to invest in renewable energy sources. This substantial commitment reflects a pivotal shift in the industry's priorities and values, indicating a collective recognition of the pressing need to combat climate change. One of the most noteworthy aspects of these efforts is the deployment of a diverse array of innovations. These innovations span various aspects of the energy sector, ranging from cutting-edge technological advancements to novel business models and operational strategies. These innovations signify a clear departure from conventional practices and exemplify the industry's willingness to adapt in response to the challenges posed by climate change and environment. In XXI century, energy sector became a modern and thriving. Moreover, energy companies are not operating in isolation. They have forged strategic partnerships and collaborations with sectors across the broader economy. This collaborative approach underscores the interconnectedness of environmental sustainability and economic prosperity. Energy companies are joining forces with other industries to leverage synergies, share expertise, and create holistic solutions that benefit not only their own operations but also the wider society. The aforementioned actions taken by energy companies have been elucidated in specific, well-defined points, offering a detailed breakdown of their

commitment to decarbonisation, investments in renewable energy, innovative pursuits, and collaborative ventures. This multifaceted approach reflects a dynamic and forward-thinking industry that is actively shaping the future of energy production and consumption in a more sustainable and environmentally responsible manner. A schematic presentation of the main elements of the research results and conducted discussion is presented in Figure 1.



RES – Renewable Energy Sources; CE – Circular Economy; CCS – Carbon Capture and Storage.

Figure 1. Schematic presentation of the main research results.

Source: Own results.

This section provides a comprehensive analysis of the strategies used by energy companies to thrive in a zero-carbon economy. The strategies are divided into the following categories:

4.1. Decarbonization of Energy Core Operations

In recent years, the need to address climate change and reduce greenhouse gas emissions has become increasingly obvious. Companies around the world are taking proactive steps to reduce their environmental footprint by focusing on reducing emissions from their core operations. The urgent need to address climate change and the transition to a low-carbon economy has driven energy companies around the world to undertake the transformation of energy production towards decarbonisation (Papadis, Tsatsaronis, 2020). Thanks to their unwavering commitment to reducing greenhouse gas emissions and minimizing their impact on the environment, these companies undertake a number of comprehensive actions aimed at transforming the energy landscape. This study looks at various actions companies are taking to reduce emissions, including fuel switching, carbon capture and storage (CCS) and process optimization, highlighting their importance in promoting a more sustainable future.

Another strategic action is moving towards the circular economy (CE). The circular economy principles can be effectively applied to the energy sector in several ways to promote sustainability, reduce resource consumption, and minimize environmental impacts (Janik et al., 2020). One of the most important factor is energy efficiency which can be introduce by designing and optimizing energy systems and processes to minimize energy waste. Companies can adopt energy-efficient technologies, implement energy management systems, and continuously improve operations to reduce energy consumption. Next common factor is renewable energy sources which are considered "circular" because they harness energy from

naturally occurring and renewable processes, minimizing the depletion of finite resources and reducing greenhouse gas emissions.

The article reviews the multifaceted activities undertaken in the pursuit of decarbonisation in energy companies.

4.2. Investment in Renewable Energy

Many energy companies have taken decisive action to reallocate their financial resources towards renewable energy projects. The direction of these investments includes the development of technologies based on energy sources such as solar, wind, hydroelectric and geothermal energy. This strategic action not only shows the clear commitment of these companies to issues related to sustainable development, but also provides many benefits for society and the environment (Abbas et al., 2023; Hailemariam et al., 2022). Energy companies make significant investments in the development of infrastructure to create favorable conditions, mainly for the development of photovoltaics and wind energy. These investments include the construction of the necessary technical infrastructure, the development of transmission and distribution networks, as well as the improvement of energy storage systems to effectively integrate these renewable energy sources into the existing power grid. The first step is often the creation of high capacity photovoltaic and wind farms that generate significant amounts of renewable energy. These installations require appropriate infrastructure, including specialized energy converters, installations to transfer energy to distribution points, as well as monitoring and management systems that ensure the effective operation of these energy sources. In addition, energy companies invest in the expansion and modernization of transmission and distribution networks. This is a key aspect that enables the efficient transport of electricity from distant photovoltaic and wind farms to end users. In addition, energy storage is becoming increasingly important in the context of photovoltaics and wind energy, which are dependent on the variability of weather conditions. Energy companies invest in the development of advanced energy storage systems, e.g. batteries. These investments in infrastructure are not only crucial for increasing the share of renewable energy in the energy mix, but also for increasing the reliability and flexibility of the entire energy system. By investing in the development of such infrastructure, energy companies play a key role in accelerating the energy transition and moving towards a more sustainable future.

4.3. Technological Innovation

Energy companies face the necessity of significant transformations. One of the key aspects of this transformation is investment in research and development in clean technologies, energy storage solutions and modernization of energy networks (Hailemariam et al., 2022). Energy companies, understanding the need to reduce greenhouse gas emissions, focus on searching for innovative solutions. This ranges from the development of more efficient

photovoltaic panels and new wind technologies to research into new energy sources such as geothermal and nuclear energy.

Modern technologies, such as high-efficiency photovoltaic panels, not only increase energy production, but also reduce installation costs, making photovoltaics more accessible to a wide group of recipients. An example of innovation is also the development of perovskite-based solar energy technology, which promises even greater efficiency and lower costs (Liu et al., 2023; Xu et al., 2023).

Other areas of research focus on energy storage, which is crucial for the efficient use of volatile renewable energy sources such as solar and wind power. High-capacity, long-life batteries are becoming more commonplace, allowing excess energy to be stored during times of abundance and used during times of scarcity.

Energy companies in many countries have aging electricity transmission infrastructure, the average age of which is over forty years, which is why this infrastructure requires investment in its modernization. Due to the rapidly growing supply of renewable energy, transmission grids require large investments to meet the technical requirements for uninterrupted transmission (Invernizzi et al., 2020). In addition, the energy market model in many countries is changing from zonal to nodal, and the one-way transmission model is slowly being replaced by a two-way model based on distributed generation and renewable energy using digital solutions based on smart, flexible networks. The new model requires a different network concept, more flexible and less dependent on centralized infrastructure (Borowski, 2022).

4.4. Collaborative Partnerships

In the energy sector, cooperation with technology companies, research institutions and other industries is a key element related to innovation and the pursuit of sustainable development and effective reduction of greenhouse gas emissions. This wide-ranging cooperation between various actors plays a key role in shaping the future of energy, bringing a number of benefits to society, the environment and the economy as a whole.

Firstly, cooperation enables the exchange of knowledge and experience between the energy sector and technology companies. Thanks to this, it is possible to use the latest technological achievements to improve energy production, improve its efficiency, implement new energy market models and increase the share of renewable sources. Examples include the development of advanced energy storage systems or the introduction of smart energy grids that reduce losses and enable more precise management of energy supply (Borowski, 2022; 2020ca).

Secondly, cooperation with research institutions allows to accelerate the process of research and development of new technologies (Wang, Su, 2020). Working together on research projects and testing prototypes allows you to shorten the time to market of innovative solutions (Popp et al., 2020). This is crucial, especially in the context of the need to quickly adapt to the increasingly restrictive standards regarding greenhouse gas emissions.

Thirdly, cooperation between the energy sector and other sectors, such as transport or industry, enables a holistic approach to reducing emissions. Thanks to this, comprehensive solutions can be developed that include both improving energy efficiency in energy production and reducing emissions in other areas of the economy (Li et al., 2022; Du et al., 2019). For example, the electrification of transport and the use of electricity in industrial processes can significantly contribute to reducing overall greenhouse gas emissions.

Another fascinating example is the close cooperation between energy companies and printed food producers. Jointly implemented projects focus on the use of advanced 3D printing technologies in food production, which aims not only to meet the demand for food, but also to reduce the negative impact of food production on the environment. This modern method of food production can contribute to a significant reduction in the carbon footprint and greenhouse gas emissions associated with traditional food production processes, such as agriculture and animal husbandry. As a result, the synergy between energy companies and printed food producers not only allows you to meet the needs of society in the field of nutrition, but also contributes to the implementation of sustainable development goals by reducing energy consumption and environmental impact (Derossi et al., 2023).

As a result, cooperation between the energy sector and various sectors of the economy contributes to the creation of a more sustainable and green energy system, economic development and the development of the financial sector, supporting innovative investments (Mukhtarov et al., 2023; Baloch et al., 2021; Bekun et al., 2019). This is a key step towards meeting emissions reduction targets and transforming the energy industry into a greener ecosystem.

4.5. Strategies used by energy companies

The research results show that active and passive adaptation strategies used by energy companies increase their ability to implement innovative activities, develop cooperation and achieve the status of a modern enterprise. In the context of a dynamic energy environment, it shows how energy companies adapt to changes, using both active approaches and passive strategies. The presented analyzes are based on research conducted in the energy sector and on a literature review. The results indicate that a balanced adaptation strategy, combining active innovation activities and passive adaptation to changes, can contribute to the long-term success of energy companies, enabling them to compete effectively and meet the requirements of the modern market (Borowski, 2020a). In addition, the implications of these strategies for the development of the energy sector and prospects for the future are discussed.

4.6. Active adaptation strategy

One approach that energy companies often choose is an active adaptation strategy. This strategy consists in proactively adapting well in advance to legal, political, environmental and ecological requirements. A key feature of this strategy is the ability to anticipate and prepare

for future changes, and even participate in the preparation of these changes. Companies choosing this path can invest in new technologies that reduce greenhouse gas emissions and in renewable energy sources, even if current regulations do not directly require it. As a result, they become more flexible and better prepared to respond to changing market conditions and social expectations. The strategy of active adaptation adopted by energy companies represents a forward-looking and proactive approach to taking into account the constantly changing landscape of legal, political, environmental and ecological requirements. The strategy has several distinct features that distinguish it as a powerful tool for sustainable development:

Proactive anticipation - characterized by the fact that energy companies that choose the strategy of active adaptation show a high ability to anticipate future changes in the regulatory, legislative and social fields. By staying ahead of the competition, they can not only meet the upcoming requirements, but also influence the development of these changes. This proactive attitude allows them to shape the trajectory of their industry towards greater sustainability.

Investment in innovation – is a hallmark of an active adaptation strategy, as it demonstrates a willingness to invest in cutting-edge technologies and practices. These investments go beyond the scope strictly required by applicable regulations (Zhang et al., 2022). For example, energy companies may choose to fund research and development initiatives to develop cleaner and more efficient methods of energy production, or they may allocate resources to research new technologies such as carbon capture and storage (Golombek et al., 2022).

Shifting towards renewable energy – is an important element in the adaptation strategy. Companies using this strategy often devote significant resources to the development and implementation of renewable energy sources (Gielen et. al., 2019). They recognize that moving away from fossil fuels is not only environmentally friendly, but also economically viable in the long run. The transition towards renewable energy sources is also a direction commonly promoted in the current world. Investments in solar, wind, hydro and other renewable energy sources demonstrate a commitment to reducing greenhouse gas emissions and promoting sustainable development.

Greater enterprise agility – means that by actively adapting to future requirements, companies become more agile and flexible in responding to changing market dynamics. They are better equipped to change their business and adapt their strategies in response to changing consumer preferences, technological advances and regulatory changes. This flexibility is a valuable asset in an industry where rapid change is increasingly becoming the norm.

Social responsibility – this is an important element included in the strategy. Energy companies applying the strategy of active adaptation see the growing importance of meeting social expectations in the field of sustainable development and responsibility for the environment. They understand that stakeholders, including consumers, investors and the general public, are increasingly holding them accountable for their impact on the planet.

By actively taking initiatives in the field of sustainable development, these companies strengthen their competences in the field of social responsibility.

Competitive advantage – this is another aspect of the adaptation strategy, as companies that actively adapt to the requirements of sustainable development often gain a competitive advantage. They can position themselves as leaders in their industry, attracting customers and investors who care about the environment. Additionally, they can access government incentives and subsidies to support renewable energy initiatives, further strengthening their competitive position.

To recapitulate, it can be said that the strategy of active adaptation adopted by energy companies is a proactive and visionary approach to meeting the challenges of our times. This includes not only complying with existing regulations, but also actively seeking opportunities to make positive change, reduce environmental impact and ensure the company's long-term success in an increasingly sustainable world.

4.7. Passive adaptation strategy

On the other hand, there is also a group of energy companies that prefer the strategy of passive adaptation. This strategy means that such companies react to requirements and regulations only when they are put into effect, not before. The choice of this strategy may result from various factors and carries both certain benefits and potential risks. There are several key elements in the passive adaptation strategy, including:

Reacting to Specific Circumstances - Companies adopting a passive adaptation strategy often argue that it is difficult to predict the exact changes in the future. In such a situation, reacting to specific circumstances once they have been established may be more effective than taking action based on speculation. Thanks to this, you can avoid investing in resources and solutions that may turn out to be unnecessary.

Minimization of Costs - in some cases, adaptation in advance may be associated with high costs. Investments in new technologies, changes in infrastructure or restructuring of operations may require significant financial outlays. Companies choosing a passive adaptation strategy may try to maintain lower operating costs, especially if current regulations do not impose direct restrictions on them.

Risks and Challenges – it should be borne in mind that the choice of a passive adaptation strategy carries some risk. Waiting for the introduction of new regulations can cause companies to be surprised by sudden changes that they will have to implement quickly. This can lead to a situation where accelerated adaptation is necessary, which can be costly and organizationally difficult.

Environmental pollution - for companies that delay their actions to protect the environment, there is a risk that their impact on ecosystems and greenhouse gas emissions remains significant. Such delays can also put companies under pressure from a society that increasingly expects companies to contribute to sustainability.

Lack of Competitive Advantage - by choosing a strategy of passive adaptation, enterprises may not gain a competitive advantage, which is achieved by competitors who adapt to changes earlier. This may affect the market position and ability to attract investors who are increasingly paying attention to sustainability issues.

To recapitulate, it can be stated that the choice of the passive adaptation strategy by energy companies is justified, especially in the context of uncertainty as to future changes and adaptation costs. Nevertheless, this approach carries some risks, especially if the growing pressure of society and environmental regulations are not taken into account. Ultimately, the effectiveness of an adaptation strategy, whether active or passive, depends on the specific circumstances, risk management capability, and long-term vision of the company.

5. Conclusion

The conducted research indicates that energy enterprises actively employ adaptive strategies, undertaking numerous actions aimed at meeting escalating environmental and ecological requirements. In the current era where sustainable development stands as a paramount priority, energy enterprises face the challenge of aligning their operations with increasingly stringent ecological standards.

An exceedingly pivotal facet of these adaptive strategies lies in the cultivation of innovations within the realm of Renewable Energy Sources (RES). These innovations wield a profound influence on mitigating adverse environmental impacts. The transition of a portion of energy production from conventional sources, such as fossil fuel combustion, to renewable sources, such as solar, wind, or geothermal energy, permits a substantial reduction in greenhouse gas emissions and other harmful substances. As a consequence, energy enterprises contribute significantly to global endeavors aimed at combating climate change.

Simultaneously, innovations in the field of RES pave the way towards a zero-emission economy. This paradigm advocates for the minimization of carbon dioxide and other polluting substance emissions through the exclusive utilization of clean energy sources. By implementing such solutions, energy enterprises contribute not only to environmental preservation but also to the creation of a more sustainable energy future.

It is noteworthy that innovations in RES also exert an impact on energy efficiency. Modern technologies enable more effective utilization of available energy sources, reducing losses in the transmission and distribution processes. This, in turn, leads to a decrease in operational costs for energy enterprises and potentially results in more favorable prices for consumers.

Furthermore, innovations in RES open the door to the development of distributed energy systems. Consequently, an increasing number of individuals and businesses can become not only energy consumers but also producers. This engenders a novel energy model wherein so-called "prosumers", individuals or organizations, generate energy for personal use or for sale into the energy grid. This amplifies societal engagement in the energy sector and contributes to greater energy independence.

In conclusion, energy enterprises that embark on adaptive strategies and invest in innovations within the sphere of Renewable Energy Sources not only meet escalating ecological demands but also contribute to the transformation of the energy sector towards a more sustainable, efficient, and democratic energy future. These endeavors are pivotal in achieving objectives related to environmental conservation and the fight against climate change.

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References

1. Abbas, J., Wang, L., Belgacem, S.B., Pawar, P.S., Najam, H., Abbas, J. (2023). Investment in renewable energy and electricity output: Role of green finance, environmental tax, and geopolitical risk: Empirical evidence from China. *Energy, 269*, 126683.
2. Baloch, M.A., Ozturk, I., Bekun, F.V., Khan, D. (2021). Modeling the dynamic linkage between financial development, energy innovation, and environmental quality: does globalization matter? *Business Strategy and the Environment, 30(1),* pp.176-184.
3. Bekun, F.V., Emir, F., Sarkodie, S.A. (2019). Another look at the relationship between energy consumption, carbon dioxide emissions, and economic growth in South Africa. *Science of the Total Environment, 655*, pp.759-765.
4. Borowski, P.F. (2020a). New technologies and innovative solutions in the development strategies of energy enterprises. *HighTech and innovation Journal, 1(2),* pp. 39-58.
5. Borowski, P.F. (2020b). Nexus between water, energy, food and climate change as challenges facing the modern global, European and Polish economy. *AIMS Geosciences, 6(4),* pp. 397-421.

6. Borowski, P.F. (2020c). Zonal and Nodal Models of energy market in European Union. *Energies, 13(16),* 4182.
7. Borowski, P.F. (2022). Digital Transformation and Prosumers Activities in the Energy Sector. In: *Intelligent Systems in Digital Transformation: Theory and Applications* (pp. 129-150). Cham: Springer International Publishing.
8. Borowski, P.F. (2022). Water and Hydropower-Challenges for the economy and enterprises in times of climate change in Africa and Europe. *Water, 14(22),* 3631.
9. Chwiłkowska-Kubala, A., Cyfert, S., Malewska, K., Mierzejewska, K., Szumowski, W. (2023). The impact of resources on digital transformation in energy sector companies. The role of readiness for digital transformation. *Technology in Society, 74,* 102315.
10. Dall-Orsoletta, A., Romero, F., Ferreira, P. (2022). Open and collaborative innovation for the energy transition: An exploratory study. *Technology in Society, 69,* 101955.
11. Derossi, A., Corradini, M.G., Caporizzi, R., Oral, M.O., Severini, C. (2023). Accelerating the process development of innovative food products by prototyping through 3D printing technology. *Food Bioscience, 52,* 102417.
12. Dilanchiev, A., Nuta, F., Khan, I., Khan, H. (2023). Urbanization, renewable energy production, and carbon dioxide emission in BSEC member states: implications for climate change mitigation and energy markets. *Environmental Science and Pollution Research,* pp. 1-13.
13. Du, H., Chen, Z., Peng, B., Southworth, F., Ma, S., Wang, Y. (2019). What drives CO2 emissions from the transport sector? A linkage analysis. *Energy, 175,* 195-204.
14. Fan, G., Liu, Z., Liu, X., Shi, Y., Wu, D., Guo, J., ... Zhang, Y. (2022). Energy management strategies and multi-objective optimization of a near-zero energy community energy supply system combined with hybrid energy storage. *Sustainable Cities and Society, 83,* 103970.
15. Gielen, D., Boshell, F., Saygin, D., Bazilian, M.D., Wagner, N., Gorini, R. (2019). The role of renewable energy in the global energy transformation. *Energy Strategy Reviews, 24,* pp. 38-50.
16. Golombek, R., Lind, A., Ringkjøb, H.K., Seljom, P. (2022). The role of transmission and energy storage in European decarbonization towards 2050. *Energy, 239,* 122159.
17. Hailemariam, A., Ivanovski, K., Dzhumashev, R. (2022). Does R&D investment in renewable energy technologies reduce greenhouse gas emissions? *Applied Energy, 327,* 120056.
18. Invernizzi, D.C., Locatelli, G., Velenturf, A., Love, P.E., Purnell, P., Brookes, N.J. (2020). Developing policies for the end-of-life of energy infrastructure: Coming to terms with the challenges of decommissioning. *Energy Policy, 144,* 111677.
19. Janik, A., Ryszko, A., Szafraniec, M. (2020). Greenhouse gases and circular economy issues in sustainability reports from the energy sector in the European Union. *Energies, 13(22),* 5993.

20. Li, R., Li, L., Wang, Q. (2022). The impact of energy efficiency on carbon emissions: evidence from the transportation sector in Chinese 30 provinces. *Sustainable Cities and Society, 82*, 103880.
21. Liu, X., Luo, D., Lu, ZH. (2023). Stabilization of photoactive phases for perovskite photovoltaics. *Nature Review Chemistry, 7*, pp.462–479.
22. Maroufkhani, P., Desouza, K.C., Perrons, R.K., Iranmanesh, M. (2022). Digital transformation in the resource and energy sectors: A systematic review. *Resources Policy, 76*, 102622.
23. Mukhtarov, S., Aliyev, F., Aliyev, J., Ajayi, R. (2023). Renewable Energy Consumption and Carbon Emissions: Evidence from an Oil-Rich Economy. *Sustainability, 15(1)*, 134.
24. Papadis, E., Tsatsaronis, G. (2020). Challenges in the decarbonization of the energy sector. *Energy, 205*, 118025.
25. Popp, D., Pless, J., Haščič, I., Johnstone, N. (2020). *Innovation and entrepreneurship in the energy sector (No. c14375)*. Cambridge, MA: National Bureau of Economic Research, 02138.
26. Qadir, S.A., Al-Motairi, H., Tahir, F., Al-Fagih, L. (2021). Incentives and strategies for financing the renewable energy transition: A review. *Energy Reports, 7*, 3590-3606.
27. Simion, C.P., Verdeș, C.A., Mironescu, A.A., Anghel, F.G. (2023). Digitalization in Energy Production, Distribution, and Consumption: A Systematic Literature Review. *Energies, 16(4)*, 1960.
28. Vats, G., Mathur, R. (2022). A net-zero emissions energy system in India by 2050: An exploration. *Journal of Cleaner Production, 352*, 131417.
29. Wang, Q., Su, M. (2020). Integrating blockchain technology into the energy sector-from theory of blockchain to research and application of energy blockchain. *Computer Science Review, 37*, 100275.
30. Xing, L., Udemba, E.N., Tosun, M., Abdallah, I., Boukhris, I. (2023). Sustainable development policies of renewable energy and technological innovation toward climate and sustainable development goals. *Sustainable Development, 31(2)*, pp.1178-1192.
31. Xu, F., Zhang, M., Li, Z., Yang, X., Zhu, R. (2023). Challenges and Perspectives toward Future Wide-Bandgap Mixed-Halide Perovskite Photovoltaics. *Advanced Energy Materials, 13(13)*, 2203911
32. Zhang, L., Saydaliev, H.B., Ma, X. (2022). Does green finance investment and technological innovation improve renewable energy efficiency and sustainable development goals. *Renewable Energy, 193*, 991-1000.