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DEVELOPMENT OF ENERGY COMPANIES BASED ON RENEWABLE ENERGY SOURCES

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Purpose: The aim of the article is to analyze the actions taken by enterprises aimed at implementing renewable energy sources (RES) in order to achieve a zero-emission economy. Analyzing these initiatives will provide insight into the development of the renewable energy sector and the impact of companies on global efforts to reduce greenhouse gas emissions.
Design/methodology/approach: The research was carried out on the basis of secondary sources and own observations. The literature on renewable energy was analyzed, including photovoltaics and reports from energy companies. The use of the desk research method based on reliable sources allowed us to obtain a large amount of data constituting the basis for drawing conclusions.
Findings: The results of the conducted research will show the direction in which energy companies are developing and which segments related to renewable energy will develop the most and fastest. The research results will support enterprises in implementing appropriate strategies related to achieving a zero-emission economy.
Practical implications: Energy companies can leverage the findings of this research to formulate and execute strategies for attaining a zero-emission economy. The insights from these studies offer direction on optimal approaches, technologies (e.g. photovoltaics farms and their orientation) and business models that can effectively mitigate greenhouse gas emissions and minimize adverse environmental effects.
Social implications: The implementation of renewable energy sources by energy companies contributes to achieving a zero-emission economy, which at the same time reduces the negative impact on the environment. These activities generate significant social effects, such as improving the quality of life, weather conditions and reducing energy poverty, enabling universal access to electricity. Additionally, the development of renewable energy technologies and improved energy efficiency can attract foreign investment, opening new opportunities for the export of green technologies, which in turn translates into economic growth and the creation of new jobs.
Originality/value: The novelty of the research is the presentation of the directions in which enterprises will develop to adapt to external requirements and enable the implementation of tasks in the field of renewable energy and energy efficiency. This provides the basis for the development of new technologies and innovative solutions. east-west orientation of photovoltaic panels. Enterprises can use this research to design and implement modern

solutions, such as digitalization, developing more efficient photovoltaic panels, building energy storage facilities or smart energy grids.

Keywords: energy, photovoltaics, renewable energy, zero-emission, strategy, innovations.

Category of the paper: Research paper.

1. Introduction

Energizing the development of renewable energy sources (RES) across all sectors is becoming a pivotal element in addressing contemporary challenges, such as energy independence, national sovereignty, and enhancing quality of life through environmental preservation. Given the current economic and political situation in Europe, restricting the ability to import energy resources from the Russian Federation, European Union member states are compelled to take actions aimed at increasing the utilization of RES (Borowski, 2022).

Renewable energy sources constitute a significant element in diversifying the electricity generation mix, crucial for the energy security of nations (Bigerna et al., 2021; Borowski, 2022). The goal by 2050 is for over half of the electricity production to originate from renewable sources. In this context, further development of wind and solar power capacities plays a crucial role, along with intensified efforts to leverage weather-independent RES.

The year 2023 marks another stage in the dynamic development of the renewable energy sector, setting a new record for the increase in installed capacity. The undeniable leader in this trend is photovoltaics, maintaining not only its dominant position but also gaining importance as the main player in the RES market (Alkan, Ates 2023). The growth in installed capacity from photovoltaics results not only from technological advancements but also from growing societal awareness and government initiatives supporting sustainable development (Biermann et al., 2022). Photovoltaic panels are becoming increasingly efficient, cost-effective, and simultaneously more accessible to various societal sectors.

Future forecasts are promising, indicating that the upward trend in installed capacity from photovoltaics will continue until 2050. This period is anticipated as a time of systematic development in this technology, encompassing both the improvement of panel efficiency and the advancement of more sophisticated energy storage systems (Agrawal et al., 2022).

The increasing installed capacity from photovoltaics reflects global efforts to transition away from traditional energy sources, such as fossil fuels, in favor of more sustainable and environmentally friendly alternatives. Companies, governments, and consumers are increasingly recognizing the benefits of using renewable energy, including reducing greenhouse gas emissions and decreasing dependence on non-renewable resources.

2. Methods

In this study a qualitative approach was applied, which is suitable for this type of scientific analysis. In the first stage, data were collected and examined from available materials already published, encompassing an extensive review of existing literature, including energy policy frameworks, scientific articles, statistical data, and industry reports. The analysis of these secondary data plays a crucial role in situating the strategies of energy companies aiming for a zero-emission economy. In the study, the qualitative approach was employed in the context of the changing energy landscape, i.e., the transition from fossil fuels to renewable energy sources and the imperative to implement sustainable development. The integration of diverse data sources and robust qualitative analysis techniques facilitated a comprehensive analysis of companies facing environmental challenges, enhancing energy efficiency and shedding light on the role of renewable energy-based energy companies in shaping the future of sustainable energy.

For the analysis of the research findings obtained through desk research, a content analysis method was 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. The integration of diverse data sources and robust qualitative analysis techniques facilitated a comprehensive analysis of companies' responses to environmental challenges.

3. Literature review

As part of the literature review, the focus was placed on analyzing key and leading scientific positions, primarily from the years 2022 and 2023, with the aim of identifying the latest trends related to the use of renewable energy sources (RES) (Zhang et al., 2023). The presented studies contribute significantly to understanding the current situation and development directions in the field of renewable energy (Zhang et al., 2023). A compelling trend in global energy production is the gradual replacement of energy from fossil fuels, such as coal and oil, with renewable energy (Liu, Feng, 2023). The primary factor influencing climate change is primarily human activity and the functioning of enterprises (Zastempowski, 2023). Electricity generated from renewable sources, coupled with research and development in renewable energy, and the implementation of new environmentally friendly technologies, significantly reduce emissions resulting from consumption and encourage environmental sustainability (Gao, Chen, 2023; Czepło, Borowski, 2024).

When analyzing the efficiency of energy production from renewable sources, particular attention must be paid to the dependence on natural conditions, especially concerning solar and wind power plants. Problems arise with their participation in the balancing process of the power system (Smolarz et al., 2023; Halkos, Tsirivis, 2023). In analyzing the energy system, dealing with planning future scenarios with a high level of variability associated with renewable energy sources is essential (Chang et al., 2021). Developing a model of the energy system requires integrating and optimizing the use of renewable energy sources, mainly consisting of hydro, solar, and biomass energy, through the implementation of new management strategies (Gul et al., 2023).

One of the crucial renewable sources is solar energy (Czepło, Borowski, 2024). Solar photovoltaics (PV) is a clean and sustainable technology with unlimited potential (Agrawal et al., 2022) and exponential growth (Naraghi, Atefi, 2022) in terms of global installed capacity (Ballif et al., 2018). Photovoltaics can play a vital role in achieving sustainable development goals (Nwokolo et al., 2023). In terms of the efficiency of photovoltaic panels, the mounting angle (Yoon et al., 2023) and orientation relative to the sun are crucial factors (Alkan, Ates, 2023; Czepło, Borowski, 2024).

Among the examined publications from the last two years, efforts were made to extract key observations and innovations regarding the use of RES. This analysis covered various aspects, such as technologies used in renewable energy production, innovative technical solutions, market trends, and the impact of RES on sustainable development. The results of the literature review shed light on the latest achievements and challenges in the field of renewable energy, revealing dynamic changes that have occurred in recent years (Alam et al., 2023; Khaleel et al., 2023). It provides current knowledge that can be significant for both the scientific community and practitioners involved in the development and implementation of renewable energy sources.

4. Results and discussion

4.1. Development of renewable energy sources

In the context of global challenges related to climate change and environmental pollution, the development of photovoltaics by 2050 can be a crucial element of energy transformation. It is expected that investments in this sector will continue, supporting the development of photovoltaic infrastructure on a global scale. As a result, photovoltaics will not only provide an increasing amount of energy but also contribute to job creation, technological innovations, and a global improvement in the environment. The forecast for the growth of installed capacity is presented in Figure 1.

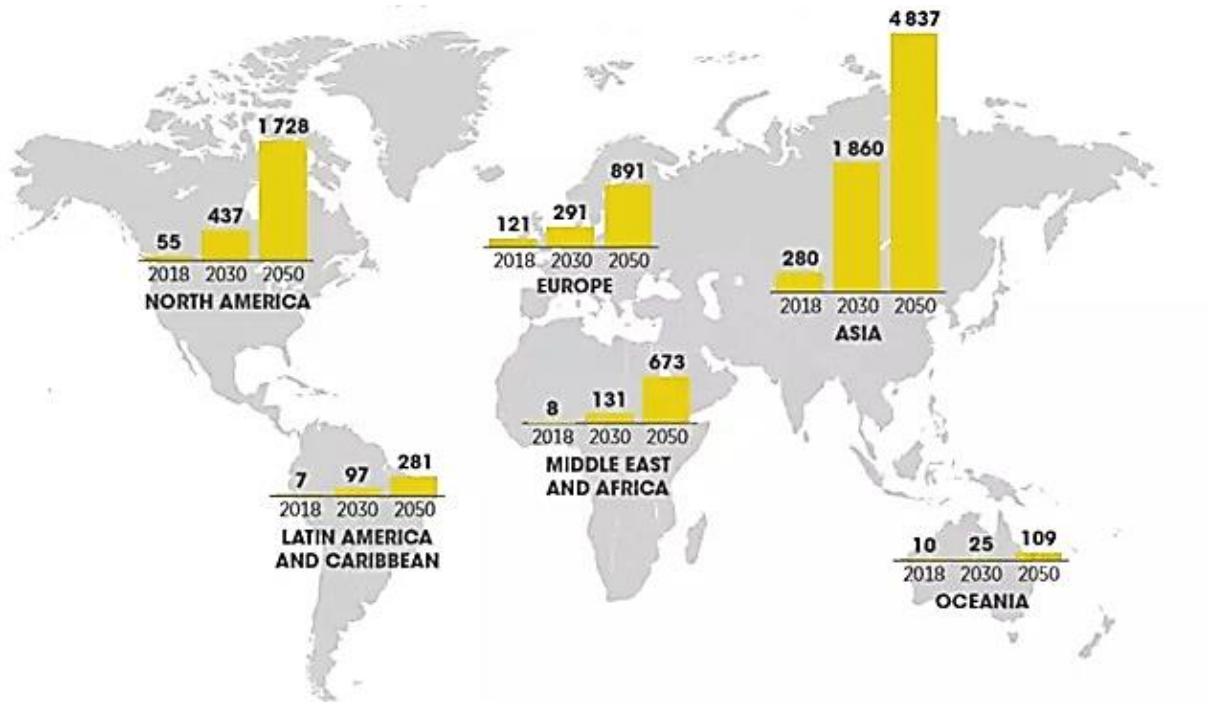

Figure 1. Solar PV installed capacities [GW].

Source: (Informatic Global Solar PV).

The global trend of constructing new renewable energy farms is clearly noticeable, with a growing installed capacity worldwide. In the recent period, out of 510 GW of new installed capacity, nearly 400 GW is attributed to solar energy (Renewables, 2023). This distinctly attests to the dominance of photovoltaics in the global energy transformation landscape (Naraghi, Atefi, 2022). Solar energy becomes the undisputed leader among renewable sources, and its increasing share in new installations confirms the effectiveness of this technology in producing clean energy. The growth in installed capacity from photovoltaics results from several key factors (Ballif et al., 2018).

Firstly, the continuously evolving technology of solar panels contributes to increased efficiency, making solar energy more attractive and cost-competitive compared to traditional energy sources.

Secondly, the growing awareness of society and governmental initiatives for sustainable energy accelerates the adoption of solar energy. Consumers, businesses, and countries increasingly recognize the benefits of using renewable energy sources, and photovoltaics become one of the most attractive solutions.

Thirdly, the ecological and economic benefits associated with solar energy translate into global governmental support. Subsidies, tax incentives, and regulations favoring renewable energy create favorable conditions for the development of new photovoltaic farms.

Forecasts suggest that the trend of increasing installed capacity from photovoltaics will persist, bringing not only increased energy production but also creating new jobs, stimulating technological innovations, and accelerating the decarbonization process of the global economy.

Solar energy becomes a key element in the global energy transformation, aiming for a more sustainable and ecological future.

In second place is wind power, followed by biomass, hydropower plants, and other energy sources. The forecast for 2040 predicts a 40% share of renewable energy in the energy mix. Figure 2 illustrates the percentage share of individual elements in the energy mix.

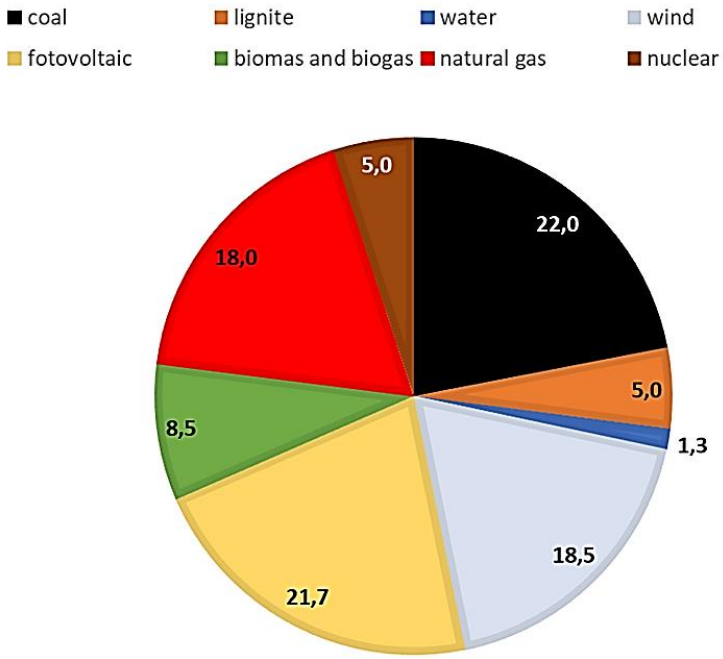

Figure 2. Energy mix in 2040.

Source: own elaboration based on (IEA, 2023).

The development of utilizing wind, solar, water energy, biomass, biogas, or geothermal heat will become a significant goal, allowing for the maximum utilization of diverse natural resources. Particularly crucial will be directing efforts towards technologies enabling the efficient use of energy in any conditions, allowing independence from weather instability (Zhang et al., 2023).

In the social and economic context, a significant aspect will be the development of renewable energy sources (RES) in energy clusters and energy cooperatives. Establishing local energy structures not only increases efficiency but also activates local communities and creates job opportunities. Furthermore, hybrid installations that combine various energy sources represent an innovative solution, enabling flexible and stable energy production.

The dynamism in the development of RES constitutes a key strategy for achieving energy independence, national sovereignty, and improving the quality of life. In the context of contemporary challenges, such as limitations on the import of energy resources, the integration of RES becomes imperative for the member states of the European Union.

4.2. Improving energy efficiency

In a general sense, energy efficiency refers to the ratio of used energy to achieved results or benefits. In the context of energy use, it involves taking actions to maximize the obtained effects based on the used energy to achieve the desired outcome with minimal energy consumption (Wojdalski et al., 2023). This encompasses various sectors such as manufacturing, transportation, industry, construction, and other economic sectors. Improving energy efficiency involves implementing measures to reduce the amount of consumed energy while maintaining the level of performance or increasing efficiency with constant energy consumption. There are several ways to enhance energy efficiency in different areas. One of the key actions is technological modernization. Technological modernization, concerning energy efficiency, aims to replace older and less efficient devices and technologies with more modern and innovative solutions that consume less energy to achieve the same or better results. Several crucial aspects can be considered to understand how technological modernization contributes to improving energy efficiency. Innovative technological solutions employ advanced materials and utilize innovative designs. Modern technologies often incorporate more advanced materials and engineering, resulting in lighter, more durable, and more efficient components. This, in turn, translates into reduced energy consumption during production, transportation, and usage. Modern materials and innovative technological solutions play a crucial role in improving energy efficiency across various economic sectors. Introducing innovative manufacturing processes based on advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), or robotics can lead to reduced energy consumption in industrial processes (Khaleel et al., 2023; Nwokolo et al., 2023). Monitoring and optimizing energy consumption are becoming more accessible through advanced production management systems. The use of modern technologies within smart energy grids allows better management of energy distribution (Zhang et al., 2023). These systems enable the optimization of consumption, the monitoring of faults, and more effective responses to changes in demand, contributing to increased energy efficiency. In energy companies and other industrial sectors, more efficient devices, machines, engines, and technologies are applied. Modern engines, machines, and devices are usually optimized for energy efficiency. They can operate more smoothly, generate less heat during operation, and more efficiently convert input energy into output energy (Wojdalski et al., 2023). Modern automation and control systems enable more precise management of processes. Optimizing production processes and introducing innovations and improvements in industrial processes help minimize energy losses. This allows adjusting energy consumption to actual needs, avoiding excessive consumption when full power is unnecessary. Smart energy management systems and the introduction of intelligent solutions enable optimal adjustment of energy consumption to changing conditions and demand. Smart energy grids enable coordinated actions of different devices to optimize energy consumption. Through technological modernization, both companies and consumers can use

energy more efficiently, saving natural resources and simultaneously reducing costs associated with its usage. This approach also has a significant impact on reducing greenhouse gas emissions and related environmental benefits. Improving energy efficiency not only reduces energy consumption but also contributes to limiting greenhouse gas emissions and mitigating the impact on the natural environment. In many cases, it is also economically beneficial as it lowers costs associated with energy consumption.

4.3. Improving the energy efficiency of photovoltaic panels through the use of an east-west orientation

Orienting solar panels in an east-west direction is a strategy aimed at optimizing the efficiency of solar energy generation by these panels (Hartner et al., 2015). In contrast to the traditional arrangement of panels facing south, an east-west orientation allows for better utilization of available solar energy throughout the day. The layout of panels on a flat roof and the east-west installation scheme are illustrated in Figure 3.

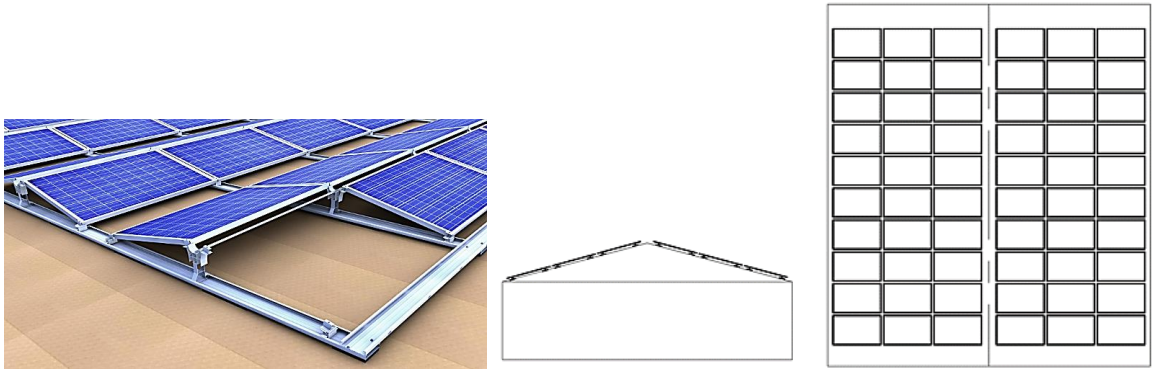

Figure 3. Installation scheme of PV panels, east-west orientation.
Source: (*PV Montagesysteme für Flachdach*; Czepło, Borowski, 2024).

Orientation of solar panels in an east-west direction also brings cost-related benefits in terms of installation and maintenance. This is derived from several key factors, such as a reduced number of installed frames, improved sunlight exposure, and easier integration with existing infrastructure. The east-west layout allows for the use of fewer supporting frames for the panel structure compared to the traditional north-south orientation. Consequently, costs related to the production, transport, installation, and maintenance of these supporting structures can be reduced. Integration with existing infrastructure is also facilitated. In many east-west layouts, panel structures can be more easily integrated with existing infrastructure, such as building roofs or areas with limited space. This, in turn, can lead to a reduction in the cost of adapting existing space for solar panel installation.

In an east-west direction, there is a lower risk of shading between panels. With an east-west panel arrangement, the risk of shading between panels is lower compared to the traditional south-facing orientation. Less shading means fewer panels are exposed to efficiency loss, translating into long-term return on investment.

Due to the reduced number of frames and better access to individual panels, maintenance, servicing, and potential repairs can be more efficient and less costly. A lower number of structures also facilitates monitoring and diagnosing potential issues. An east-west orientation provides greater flexibility in installation planning, allowing for better adaptation to specific terrain conditions and avoiding costly land modifications. Orienting solar panels in an east-west layout can bring cost benefits associated with fewer installed frames, a significant factor when assessing the feasibility of photovoltaic projects. This approach may be particularly attractive in situations where infrastructure costs are a key decision-making factor.

East-west panel orientation allows for the even utilization of solar energy throughout the day. As a result, energy generation begins early in the morning on the east side, peaks at noon, and continues until sunset. This sustainable temporal distribution can be especially beneficial for energy systems that require constant access to electricity throughout the day. Orienting panels east-west, rather than southward, enables the generation of more energy in the morning, with panels facing west generating power in the late afternoon.

Compared to a unidirectional panel arrangement, an east-west orientation helps minimize production losses during momentary shading or the appearance of clouds, which can affect panel efficiency. This makes the system more resilient to variable weather conditions. Improving energy efficiency through east-west orientation is particularly effective in regions with unstable weather conditions or changing sunlight intensity during the day.

East-west orientation may be particularly effective in areas with specific geographic conditions, such as narrow valleys, where natural obstacles may affect access to sunlight from one direction. Similarly, favorable placement occurs in urban areas where access to space may be limited. East-west orientation can be a more flexible option, allowing for panel installation on building roofs without the need for always precise south-facing alignment.

However, the decision to orient panels east-west should be tailored to specific local conditions, sunlight availability, and installation goals. In some cases, especially in areas with more stable sunlight access, traditional south-facing orientation may still be more efficient.

5. Summary

The use of renewable energy sources is a crucial factor in reducing greenhouse gas emissions, which becomes essential in the context of global challenges related to climate change. Simultaneously, the transition from fossil fuels to renewable energy sources allows for independence from raw material imports, especially in the context of current difficulties associated with the energy crisis.

Increasing the share of renewable energy sources in the energy mix has the potential for development, enabling the evolution of the economy towards a zero-emission model. This is not only a step towards sustainable development but also a significant factor influencing the improvement of air quality and the overall environmental condition. Energy efficiency plays a non-negligible role in the context of sustainable energy use, both in energy companies and on an economy-wide scale. Effective energy management and process optimization form the foundations upon which sustainable development is built.

Photovoltaics, as one of the most dynamically developing areas of renewable energy, plays a crucial role in this transformation. Research on optimal technical solutions, such as the orientation of photovoltaic panels in an east-west layout, is a significant element in the pursuit of maximizing the efficiency of solar energy production.

Therefore, the continuation of scientific research, investments in the development of modern technologies, and the strengthening of international cooperation in the field of renewable energy sources are crucial for building a sustainable energy future. Striving for a zero-emission economy requires joint efforts, innovative approaches, and ongoing commitment from both the public and private sectors.

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