Application of alternative sources of energy resources: Economic aspects

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ABSTRACT
Abstract. The topic of research related to alternative energy sources is relevant, since with the constant growth of the population and the development of industry around the world, the demand for energy continues to increase, at a time when traditional energy sources (coal, oil, and gas) are limited and subject to exhaustion. Alternative energy sources offer new opportunities to meet the growing demand for energy, they can provide more stable prices and reduce dependence on energy imports, and do not emit greenhouse gases or pollute the environment. The purpose of this paper is to study the economic viability and potential of alternative energy sources in order to assess their impact on the economy and identify opportunities and challenges. Among the methods used, the analytical method, the statistical method, the functional method, the system analysis method, the deduction method, the synthesis method and the comparison method were applied. The study analysed financial mechanisms that promote the development of alternative energy sources, such as subsidies, tax incentives and investments in renewable energy sources. The effectiveness of these mechanisms and their impact on the development of the industry was studied. Special attention was paid to the economic risks associated with alternative energy sources, including the instability of prices for equipment and technologies, as well as changes in legislation and regulation. The current state and dynamics of the market for alternative energy sources were analysed, as well as the growth potential and the share of alternative energy sources in the overall energy system were determined. The positive impact of the use of alternative energy sources on the economy and society is assessed. The results obtained are of practical value and can be used to make decisions related to the use of alternative energy sources and improve this process at a new level.

KEYWORDS
economic efficiency; financial mechanisms; savings; rational use of resources; green economy

1. Introduction

In the context of the constant growth of energy consumption and the instability of traditional sources of energy resources, interest in alternative energy sources from an economic point of view is rapidly increasing. Alternative energy sources, including
solar energy, wind energy, hydropower, geothermal energy and biomass, present new opportunities to diversify the energy portfolio, reduce dependence on fossil fuels and reduce the negative impact on the environment. According to the International Energy Agency, global energy demand is expected to increase by more than 25% by 2040 “2332154:30799966” (2019). Expanding the use of alternative energy sources is becoming essential to ensure a sustainable energy future. Also, according to the International Renewable Energy Agency, the cost of solar energy has fallen by 82% since 2010, and the cost of wind energy has decreased by 39% Irena (2023). This makes alternative energy sources more accessible and competitive with traditional energy sources. For successful development and decision-making on the introduction of alternative energy sources, it is necessary to take into account their economic component. Issues of cost of production, installation, and operation of alternative systems, the effectiveness of financial mechanisms, the impact on the energy market, risks and benefits, as well as socio-economic consequences become important factors for research. The analysis of economic risks and benefits is associated with an assessment of the stability of prices for equipment and technologies, changes in legislation and regulation, as well as an assessment of the positive impact of the use of alternative energy sources on the economy and society.

D.K. Yestayeva et al. argue that today the world energy industry is dominated by traditional sources of energy resources, however, alternative energy sources, due to their renewability and environmental friendliness, are increasingly attracting attention Yestayeva, Ahmetbekova, and Yerkongyr (2019). Kazakhstan is actively promoting the development of alternative energy, which is an integral part of the global process to increase the share of renewable energy sources in total production. Alternative energy sources including solar, wind, hydropower and geothermal power, according to G.K. Shakulikova and S.M. Akhmetov, have clear advantages Shakulikova and Akhmetov (2021). Their use does not deplete natural resources, does not deplete the environment, and they are not subject to fluctuations in oil or gas prices. This creates stability and predictability in energy supply and reduces dependence on energy imports. According to B.A. Baitanaeva et al., the development of alternative energy sources can stimulate economic growth and job creation Baitanaeva, Shaikhutdinova, and Bisultanova (2019). The introduction of new technologies and infrastructure related to alternative energy requires significant investment and leads to the development of the industry and innovation. As a result, it is possible to increase the level of employment and contribute to the development of local economies.

M.T. Kozhikov and B.A. Irasylova believe that over time, the cost of producing alternative energy sources is significantly reduced Kozhikov and Irasylova (2022). Technological progress and scaling up of production allow improving the efficiency of alternative systems and reducing their cost. This makes them increasingly competitive with conventional energy sources. The strong demand for alternative energy sources also stimulates investment in research and development of new technologies, which further increases their efficiency. Alternative sources of energy resources have great potential to ensure a sustainable future. According to A.Zh. Shaimerdenova, it is necessary to apply an integrated approach to the development and use of these sources, taking into account economic, social and environmental factors, as well as providing support and cooperation with all stakeholders Shaimerdenova and Zh (2019). Investments in alternative energy sources lead to the development of infrastructure and technologies, which contribute to the creation of new business opportunities and attractive markets.

The purpose of the study is to analyse alternative sources in order to assess their financial viability, effectiveness, and potential in the context of ensuring the sustainable
development of Kazakhstan. Realization of this goal will make it possible to determine the optimal strategies and financing mechanisms for the development of alternative energy sources.

2. Materials and Methods

To study the topic, the study of official documents and reports was involved, namely: reports of the Ministry of Energy of the Republic of Kazakhstan [https://www.gov.kz/memleket/entities/energo?lang=en (2023)] and the International Renewable Energy Agency (IRENA) [Irena (2023)]. Conducting a scientific study on the study of alternative sources of energy resources was carried out using methods that reveal the content of the object. Using the analytical method, it was possible to investigate data related to the economic aspects of alternative energy sources. It was possible to study the current situation in the alternative energy market, identify the main trends and problems, understand the advantages and limitations of such sources. The statistical method was applied to study the statistical data related to the use of alternative energy sources in various regions and countries. It made it possible to evaluate production volumes, consumption, investments and other indicators in order to determine development trends and predict future demand for alternative energy resources. The application of the functional method helped to explore the possibilities of alternative energy sources in terms of their application in various sectors of the economy, as well as to determine what functions and tasks can be solved with their use, to evaluate their contribution to economic efficiency and sustainability.

The system analysis method was applied to study complex relationships and the impact of alternative energy sources on the economic system as a whole. It made it possible to assess the economic, social and environmental aspects of the use of alternative energy and to identify possible interactions and effects within the system. With the help of the deduction method, it was possible to understand the general patterns and principles, based on existing knowledge and research in the field of alternative energy sources. The synthesis method has allowed different elements and ideas to be brought together to create integrated and sustainable solutions that can be cost-effective. The comparison method was used to compare different alternative energy sources in terms of their cost-effectiveness. It allowed a comparative analysis of various parameters, such as cost of production, potential for scaling, reliability and other factors, in order to determine the most suitable options for specific economic conditions and needs.

The study was conducted with the disclosure of some aspects, including theoretical and practical components. The theoretical aspect includes the study of concepts, models, and approaches related to alternative energy sources from an economic point of view. It consists of an analysis of economic theories, such as the theory of investment, the theory of supply and demand, the theory of pricing. The study also contains an examination of the concept of sustainable development and its relationship with alternative energy sources. Another aspect of the study was the analysis of real data, empirical studies and case studies of the application of alternative energy sources in the real economic environment. The study includes a study of the market for alternative energy sources, including an analysis of demand, supply, pricing and competitive environment. Based on the results obtained, the necessary recommendations were considered in highlighting specific problems in the efficiency of alternative energy sources, which will contribute to solving issues and developing the economy. As a result, these actions were applied to consider the feasibility of using alternative energy sources for
the successful development of the economy and the country as a whole.

3. Results

Energy is currently based mainly on the use of organic fossil fuels, which leads to environmental pollution, an imbalance in the thermal equilibrium of the atmosphere and gradual global climate change. The uneven distribution of mineral resources and the inability to increase hydrocarbon production in sufficient volumes to meet the projected demand for electricity and heat, lead to economic and political crises and create tension in the world. More than half of all harmful anthropogenic emissions, including greenhouse gases, come from the use of hydrocarbon fuels Gielen et al. (2019). All over the world, work is actively underway to solve the problem of energy shortage and the transition to alternative energy sources, which not only provide energy demand, but also do not pollute the environment. This is a strategically important task, which is related to ensuring the security of the country and its future advancement in the field of electricity and infrastructure. The development of the electric power industry can help improve other sectors of the economy and stimulate the work of export-oriented industries with low energy consumption. It is also important to take into account the availability of available primary energy resources, such as, for example, cheap coal.

The development and deployment of various alternative energy sources, which include wind power, solar energy and small hydropower plants, can help diversify the energy sector and provide a stable and reliable electricity supply, especially for remote areas where there is a shortage of electricity. At the same time, ensuring reduction of emissions and negative impact on the environment. The use of alternative energy sources has a number of significant economic benefits. First, it can reduce dependence on fossil fuels such as oil, gas, and coal. Avoiding the use of scarce resources reduces the risk of shortages and instability in world energy markets, and reduces dependence on artificially expensive imports. This contributes to economic stability and ensures independence in the energy sector. Second, alternative energy sources have the potential to reduce operating costs. For example, solar and wind power plants require no fuel to operate and have low maintenance costs once installed. This reduces operating costs and increases the economic efficiency of the system. Thirdly, with the development of technology and the scaling of production, the cost of producing alternative energy sources is decreasing. Solar panels, wind turbines and other equipment are becoming more affordable and affordable. This makes alternative energy sources competitive with traditional ones, which can lead to a reduction in the cost of electricity for consumers and stimulate economic growth Alper and Öğuz (2016).

The development of alternative energy sources is largely dependent on financial mechanisms such as subsidies, tax incentives and investments in renewable energy sources. Government subsidies are provided to reduce the cost of installing and operating alternative energy sources. This may include subsidies for the purchase of equipment, government grants, and soft loans. Subsidies help reduce initial investment costs and make alternative energy sources more attractive to investors. Tax incentives and incentives may be provided to investors and enterprises using alternative energy sources. This may include property tax exemptions, tax credits for investments, and tax credits for operating expenses for a certain period of time. Tax incentives can reduce the financial burden on investors and increase their profitability Yang, He, Xia, and Chen (2019). Banks, funds and investment companies can actively invest in projects related to alternative energy sources. This can be done through the provision of loans,
the purchase of shares or participation in joint ventures. Investments provide access to the necessary capital for the construction and development of alternative energy projects Taghizadeh-Hesary and Yoshino (2020).

These financial mechanisms promote the development of alternative energy sources, reduce investor risks, reduce production costs and improve economic efficiency. They play a key role in the transition to sustainable and clean energy. The state of alternative sources of energy resources in Kazakhstan can be relatively characterized as promising, but still developing. Kazakhstan has significant potential for the use of alternative energy sources and seeks to diversify its energy system, reducing dependence on traditional fossil fuels. Table 1 presents the development of alternative energy sources in Kazakhstan.

**Table 1. Development of alternative energy sources in Kazakhstan**

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Number of objects</td>
<td></td>
<td>26</td>
<td>48</td>
<td>51</td>
<td>57</td>
<td>67</td>
<td>90</td>
<td>115</td>
<td>134</td>
<td>130</td>
</tr>
<tr>
<td>Total installed capacity, MW</td>
<td></td>
<td>117.52</td>
<td>251</td>
<td>295.7</td>
<td>342.8</td>
<td>531</td>
<td>1050.1</td>
<td>1634.7</td>
<td>2010</td>
<td>2400</td>
</tr>
<tr>
<td>Generation volume billion kWh</td>
<td></td>
<td>0.58</td>
<td>0.7</td>
<td>0.93</td>
<td>1.1</td>
<td>1.35</td>
<td>2.4</td>
<td>3.24</td>
<td>4.2</td>
<td>5.11</td>
</tr>
<tr>
<td>Share of energy generation in total</td>
<td></td>
<td>0.62</td>
<td>0.77</td>
<td>1</td>
<td>1.08</td>
<td>1.26</td>
<td>2.3</td>
<td>3</td>
<td>3.2</td>
<td>4.53</td>
</tr>
</tbody>
</table>


In 2022, there are 130 alternative energy facilities operating in the country with a total installed capacity of 2400 MW. Among them are 46 wind power plants with a capacity of 958 MW, 44 solar power plants with a capacity of 1148 MW, 37 hydroelectric power plants with a capacity of 280 MW and 3 bioelectric power plants with a capacity of 1.77 MW. As a result of the operation of these stations, 5.11 billion kWh of electricity was generated in 2022, which is 4.53% of the total electricity production. For example, in China and the United States, the two largest consumers of energy, the share of alternative sources is about 10-15% of total production, while in countries such as Denmark, Germany and Sweden, the share of renewable energy resources can be a significant part, exceeding 50% Irena (2023). One of the most promising alternative sources in Kazakhstan is solar energy. The solar potential of the country is very high, especially in the southern regions. Currently, solar power plants of various capacities are being developed and built in Kazakhstan. However, the share of solar energy in the total energy balance of Kazakhstan is still low compared to traditional sources. Wind energy also has potential for development in Kazakhstan. The country has vast areas with high wind speeds, especially in the western regions. Wind farms are currently operating in Kazakhstan, and their number is gradually increasing. However, the share of wind energy in the energy system is still small. Hydropower is also of some importance in Kazakhstan, especially in the northern regions of the country. There are small hydroelectric power plants that use the potential of rivers and reservoirs. However, the potential of hydropower in Kazakhstan has not yet been fully used Baktymbet, Ukubassova, Baktymbet, Baktymbet, and Bakirbekova (2020).

Compared to other countries such as Germany, China, the US, and India, which are leaders in the field of alternative energy sources, Kazakhstan may be lagging behind in the development and use of such energy sources. However, Kazakhstan is gradually increasing the share of renewable sources in its energy system. An important aspect of the economic state of alternative energy sources is the cost of production and operation. The costs of building and maintaining alternative energy systems can be high, especially in the early stages of development. However, as technology advances and production scales up, the cost of producing renewable energy tends to decrease, making it more
competitive with conventional energy sources. Figure 1 shows the installed renewable energy capacity for 2021 of the leading countries in this field.

![Figure 1. Installed capacity of renewable energy, kW](chart)

Source: Irena (2023).

China occupies a leading position among countries, being the largest producer and consumer of alternative energy in the world. With a focus on developing solar and wind energy, as well as hydropower and nuclear power, China is aiming to reduce its dependence on fossil fuels and reduce greenhouse gas emissions. In the US, alternative energy sources play an important role in national energy policy. The solar and wind energy sectors are the most developed. Various states in America set their own goals for increasing the share of renewable energy, and the federal government provides tax credits and subsidies for the development of alternative energy sources. India is also a country with a dynamic alternative energy market. The fields of solar and wind energy, as well as hydropower and biomass, are actively invested in the country. India has ambitious plans to increase the share of renewable energy and reduce greenhouse gas emissions. Figure 2 provides information on investments in the development of renewable energy in various countries of the world for 2021.
China, the US, Japan, and the UK are currently leading the way in renewable energy investment. Since the start of tracking this data, global investment in the wind and solar energy, biofuels, biomass, waste, and small hydropower sectors has increased by almost 10 times. Over the past 20 years, annual investments in clean energy have increased from $33 billion to more than $300 billion (Zahoor, Khan, and Hou 2022). Kazakhstan is making significant efforts to develop alternative energy sources, but there is still room for growth and comparison with leaders in this field. As a result of lower costs for solar photovoltaic systems and onshore wind farms, new renewable energy sources are becoming more affordable and competitive with new fossil fuel power plants. However, they are also starting to surpass even the operating costs associated with existing coal-fired power plants (Saidi and Omri 2020). Table 2 presents the capacity of inefficient existing coal-fired power plants, as well as the annual savings in electricity generation by using alternative sources instead of coal, reducing CO\(_2\) emissions for 2021. This data allows analysing the economic benefits of switching from coal to renewable energy, including lower electricity generation costs and reduced greenhouse gas emissions. Source: Irena (2023).

The analysis carried out in Germany and Bulgaria shows that all coal-fired power plants have higher operating costs compared to new solar and wind systems. In Kazakhstan, as well as other CIS countries, the operating costs of coal-fired power plants may be higher due to the cost of CO\(_2\) emissions. However, operating costs for coal-fired plants are generally lower in the US and India, mainly due to the absence of significant CO\(_2\) costs. But at the same time, they have higher costs compared to solar and wind power plants, which are competitive in terms of cost (Irena 2023). The widening gap between the costs of new solar and wind farms and the operating costs of existing coal plants highlights the significant economic potential that comes from prematurely phasing out inefficient coal applications.
Table 2. The result of replacing coal with new solar and wind power plants

<table>
<thead>
<tr>
<th>Countries</th>
<th>Coal-fired power plants, which have higher operating costs than new solar and wind farms (GW)</th>
<th>Annual savings achieved by replacing coal with new solar and wind farms (USD/year)</th>
<th>Annual emission reductions CO₂ (MtCO₂/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>29 29</td>
<td>3.2</td>
<td>98</td>
</tr>
<tr>
<td>India</td>
<td>194 142</td>
<td>6.3</td>
<td>642</td>
</tr>
<tr>
<td>USA</td>
<td>189 150</td>
<td>5.5</td>
<td>331</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>3.7 3.7</td>
<td>0.7</td>
<td>18</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>19 19</td>
<td>2.8</td>
<td>67</td>
</tr>
<tr>
<td>World</td>
<td>1137 810</td>
<td>32</td>
<td>2973</td>
</tr>
</tbody>
</table>

The use of alternative energy sources is associated with certain economic risks, including volatility in equipment and technology prices, as well as changes in legislation and regulation. The market for alternative energy sources may be subject to fluctuations in the prices of solar panels, wind turbines and other equipment. This can be caused by factors such as changes in supply and demand, external economic conditions, and technological innovations. Price volatility can affect the economic viability of projects and affect their profitability (Adefarati and Bansal, 2019). Governments make changes to the system of tax rates, energy tariffs or certification requirements. Development and construction of alternative energy projects require significant investments. Lack of funding or access to credit can be a significant risk. This can be caused by financial instability, limited access to financial resources, or high interest rates (Xu, Wei, Ji, Wang, and Gao, 2019). Alternative energy sources are relatively new technologies and there are risks associated with their reliability and performance. For example, technical problems, unexpected equipment failures, or poor performance can affect the profitability of a project.

To mitigate the economic risks associated with alternative energy sources, various strategies and solutions can be proposed. Diversifying the project portfolio is an important approach. Investors and developers can reduce risk by spreading their investment among different types of alternative energy sources, regions, and countries. Government support and policy stability play an important role in risk mitigation. Government support in the form of subsidies, tax breaks and long-term energy contracts can help mitigate financial risks and ensure the stability of project returns. The continuous development of technologies in the field of alternative energy sources allows reducing equipment costs, increasing the efficiency and reliability of systems, as well as improving their economic feasibility.

4. Discussion

A scientific study conducted among alternative energy sources confirms their economic importance at the present time. Fossil fuels are limited resources, while renewable energy sources have the potential to be constantly available and continuous. Solar and wind energy, for example, are inexhaustible resources based on natural processes in nature. In recent years, the cost of solar and wind energy technologies has dropped significantly, making them more competitive with traditional energy sources. Reducing the cost of equipment, developing technologies and scaling up production contribute
to an increase in the economic efficiency of alternative energy sources. They can help create new jobs. Investment in renewable energy development stimulates innovation and the development of new technologies, which can lead to the creation of new jobs and increased economic growth. Also, solar energy, wind energy, geothermal energy, biomass, and hydropower are considered more environmentally friendly because they do not emit greenhouse gases and other harmful substances that contribute to climate change and environmental pollution.

This study shows that alternative energy sources have their own challenges and limitations. Important factors are high installation and maintenance costs of equipment, volatility in technology prices, and changes in legislation and regulation that may affect the investment attractiveness of this industry. Alternative energy sources are a promising and important area of development that can contribute to sustainable economic development, reduce greenhouse gas emissions and reduce dependence on fossil fuels. However, their successful implementation requires innovation, investment, and stable political and regulatory frameworks.

G. Choi et al. analysed in their study the economic efficiency of various alternative energy sources in comparison with traditional ones Choi, Huh, Heo, and Lee (2018). It has been found that alternative energy, such as solar and wind, may require significant investment in equipment installation. However, in the long run, they may prove to be more cost-effective, especially given the reduction in the cost of technologies and the increase in their efficiency. Evaluation of the economic return on investments in alternative energy allows assessing their potential as long-term sources of income. This includes analysis of the payback time of investments, internal rate of return (IRR) and other financial indicators. Analysis of the economic efficiency of alternative energy sources is an integral part of the decision-making process in the energy sector. It allows evaluating the financial aspects and results of the introduction of alternative energy sources, as well as identifying the advantages and limitations of associated technologies. At the same time, it is necessary to take into account the associated risks and challenges that may arise during the transition to alternative energy sources.

X. Deng and T. Lv carried out in their work modelling of energy markets, taking into account the growing share of alternative energy sources Deng and Lv (2020). This made it possible to assess the impact of various factors, such as changes in energy prices, energy policy and regulation, on the economy and the market share of alternative energy sources. Changes in energy prices play an important role in determining the efficiency and attractiveness of alternative energy. Accounting for energy policy and regulation is also an important aspect of modelling. Energy policies, such as the introduction of incentives for the development of alternative energy sources and the regulation of greenhouse gas emissions, have a significant impact on the development of the energy sector. All these factors are interrelated and can influence the economy and the market share of alternative energy sources. In order to achieve sustainable energy development, it is important to conduct comprehensive analyses that take into account these factors and determine the optimal strategies for the development of alternative energy sources.

In their study, L. He et al. analysed investments in alternative energy sources and financing mechanisms He, Liu, Zhong, Wang, and Xia (2019). The study includes an examination of the impact of various financial instruments such as subsidies, tax breaks, green bonds and venture capital investments on the development and attractiveness of alternative energy sources. Investing in alternative energy sources reduces dependence on imports and ensures a more sustainable and independent energy future. Improving the efficiency of renewable energy system components stimulates the development of
new industries and the creation of new technology companies, which contributes to economic growth and increases the competitiveness of the country on a global scale. It is important to note that investments in alternative energy sources not only help to reduce dependence on energy imports, but also have the potential to create new jobs and stimulate economic growth. Financing mechanisms and investments in alternative energy sources help to better understand the economic aspects of this topic. They offer valuable insights for designing effective strategies to stimulate and develop alternative energy sources, contributing to a sustainable and clean energy future.

In their work, M.H. Rehmani et al. compared the average energy costs for consumers using different energy sources Rehmani, Reisslein, Rachedi, Erol-Kantarci, and Radenkovic (2018). The study includes an assessment of the cost of energy for industrial, commercial and residential consumers and allows determining which energy sources can be most cost-effective for end users. Energy sources may vary depending on many factors such as region, availability of resources, energy infrastructure, legislation. However, sources such as solar energy, wind energy and hydropower are considered more cost-effective. Every factor must be considered when choosing the optimal source of energy, including resource availability, infrastructure, legislation, and energy prices. However, it should be noted that the economic benefits of alternative energy sources may vary depending on many factors, including specific conditions and resources in each region. For example, solar power may be more cost-effective in regions with abundant sunshine, while hydropower may be preferred in regions with access to water resources.

S.A.R. Khan et al. assessed in their study the environmental and economic benefits of developing alternative energy in different regions, using a comparative analysis of the material intensity (resource intensity) of this sector of the economy Khan, Zhang, Kumar, Zavadskas, and Streimikiene (2020). According to their study, renewable energy sources, which are able to effectively reduce human impact on the environment and have a low material intensity in relation to production, are considered as the most promising from an environmental and economic point of view. In particular, wind and solar energy are recognized as the most promising in this context. However, biofuel-fired plants, as well as small hydropower plants, have lower efficiency compared to large ones. Such an analysis of the environmental and economic benefits of various alternative energy sources allows more accurately determining the most efficient and sustainable energy solutions. He emphasizes the need to develop and encourage the use of wind and solar energy, and warns against the thoughtless use of biofuels and small hydropower in certain contexts. However, it should be taken into account that the choice of the most efficient and sustainable energy solutions depends on the specific region, its climatic, geographical and economic features.

In general, alternative energy sources represent an important and promising area in the energy sector. The study and analysis of the economic efficiency of such energy sources make it possible to assess their role in the energy system and take measures to stimulate and develop them. They have the potential to reduce dependence on traditional energy sources, reduce greenhouse gas emissions and create a sustainable and independent energy future. However, for successful implementation, it is necessary to take into account economic, technological, regulatory and social aspects, as well as to develop effective financing and incentive mechanisms.
5. Conclusions

In the course of the study, the role of alternative sources of energy resources in the modern world was characterized, and their economic advantages were also highlighted. These include reducing dependence on fossil fuels, reducing operating costs, advancing technology and scaling production. The financial mechanisms on which the development of alternative energy sources depends were described. These mechanisms include subsidies, tax incentives and investments in renewable energy sources. In the course of the study, the state of alternative energy sources in Kazakhstan was characterized. The country has significant potential to tap into such sources and is seeking to diversify its energy system. At the end of 2022, there are 130 alternative energy facilities operating in the country with an installed capacity of 2400 MW, the generation of such stations is 5.11 billion kWh or 4.53% of the total electricity production. The most promising alternative energy sources in Kazakhstan are solar and wind energy and hydropower. Tables were compiled with the installed capacity of renewable energy and investments in this area. Leading countries in this area include China, the United States, India and Japan. Annual savings in electricity production were determined when using alternative sources instead of coal, as well as reductions in CO\text{2} emissions in different countries. The economic risks of using alternative energy sources were also identified, which include instability in prices for equipment and technologies, changes in legislation and regulation. Various strategies and solutions have been drawn up to mitigate such risks. Diversification of the project portfolio, government support, continuous development of technologies in the field of alternative energy sources are among such solutions. In conclusion, it can be noted that alternative energy sources from an economic perspective show significant potential for creating a sustainable and efficient energy system. Further research may be aimed at a deeper analysis of the economic impact of investments in alternative energy sources on the overall economy.

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None.

Authors’ contributions

G.K., Y.G., R.P., K. K. and A.S. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

References


