COMPREHENSIVE IDENTIFICATION OF RISKS IN THE VARIOUS PHASES OF INVESTMENTS IN RENEWABLE ENERGY SOURCES PROCESS

Rafał ŚPIEWAK[1], Aleksandra SEROKA[2], Mustafa DEMİREL[3]*, Ahmed NAAYIF[4]

[1] Faculty of Economics, University of Gdańsk; rafal.spiewak@ug.edu.pl, ORCID: 0000-0002-8030-4818
[2] Doctoral School of Humanities and Social Sciences of University of Gdańsk; aleksndra.seroka@vp.pl, ORCID: 0000-0002-1191-8015
[3] Doctoral School of Humanities and Social Sciences of University of Gdańsk; mustafademirel999@gmail.com, ORCID: 0009-0001-6720-0790
[4] Business School of Sichuan University; ahmed.naaiyf@gmail.com, ORCID: 0000-0003-2825-2261
* Correspondence author

Introduction/background: The article draws attention to the wealth of sources devoted to determining the risks related to individual (different) stages of the RES investment process. At the same time, no sources presenting a summary of these risks in a comprehensive form have been identified. The article meets the expectations of investors in RES, providing them with information about the most important risks accompanying the implementation of investments in RES, at each of its stages.
Aim of the paper: The aim of this article is to present the results of a comprehensive analysis of risks in the investment process for the RES industry.
Materials and methods: The paper uses research methods consisting of text, literature, and documentation reviews as well as non-participant observation and analysis with synthesis.
Results and conclusions: The result of the analysis is a list of risks at each stage of the investment process dedicated to investments in RES. They have been classified in terms of the scale of impact from the perspective of the decision-making dimension.
Keywords: renewable energy sources, risk management, investment, classification, risk.

1. Introduction

China, the United States and Germany are leading the way in renewable energy investment, with a combined share of 54.5%. India, Brazil and Japan have also increased their spending on green energy, while Poland is also beginning to show increased interest (Kwinta, 2022). This can be attributed to the high electricity prices that make renewable energy more attractive. Interest in renewable energy is also growing in Poland. However, it should be noted that due to the specificities of the local natural resource market (coal is dominant), the main motivation for these activities is EU regulations (Seroka, 2021a) because the local natural resource market is dominated by coal. Directive 2003/87/EC of the European Parliament was the outcome of the arrangements in the Kyoto Protocol (December 1997) and is regarded as the first document imposing obligations on Poland in the realm of renewable energies (Paska et al., 2022). This document is an addition to the United Nations Framework Convention on Climate Change (May, 1992). There is an observable rising requirement for energy, which further affirms the necessity for more investments in the processing industry. In 2022, the rate of increase of electricity demand will decrease significantly. The economic climate in 2021 saw a marked improvement due to the easing of Covid-19 restrictions, resulting in a 6% increase in global electricity demand. This growth is expected to slow to 2.4% in 2022, which is similar to the growth experienced between 2015 and 2019. Despite this slowdown, electricity demand remains on an upwards trajectory. The European Union's climate policy will serve to further increase the share of renewable energy sources (RES) in the energy mix of member countries. As of November 2022, Poland's installed capacity for all power sources stands at 60 GW, 22 GW of which is renewable and therefore makes up over 35% of the total. Figure 1 below outlines the growth drivers of this sector in terms of percentages.

		Type of RES power plants					
		Water	**Wind**	**Biogas**	**Biomass**	**Photovoltaics**	**SUM**
Installed capacity [MW]	**11/2021**	976,2	7000,7	255,5	912,3	7140,8	16286
	11/2022	978	7864,8	279,5	968,6	11924	22015
Dynamics		**100,2**	**112,3**	**109,4**	**106,2**	**167**	**135,2**

Figure 1. Capacity of RES that have been installed by source type in November 2021 and November 2022.

Source: Rynek Elektryczny (2022). Moc zainstalowana OZE wzrosła do ponad 22 GW, https://www.rynekelektryczny.pl/moc-zainstalowana-oze-w-polsce/, 4.03.2023.

In Poland, photovoltaic power generation is the leading form of renewable energy, making up almost 54% of the nation's total installed renewable energy capacity. As of November 2022, close to 12 GW of photovoltaic power generation had been installed. Wind energy was the second highest, with an installed capacity of 7.8 GW, accounting for 36% of the country's renewable energy capacity (Figure 2).

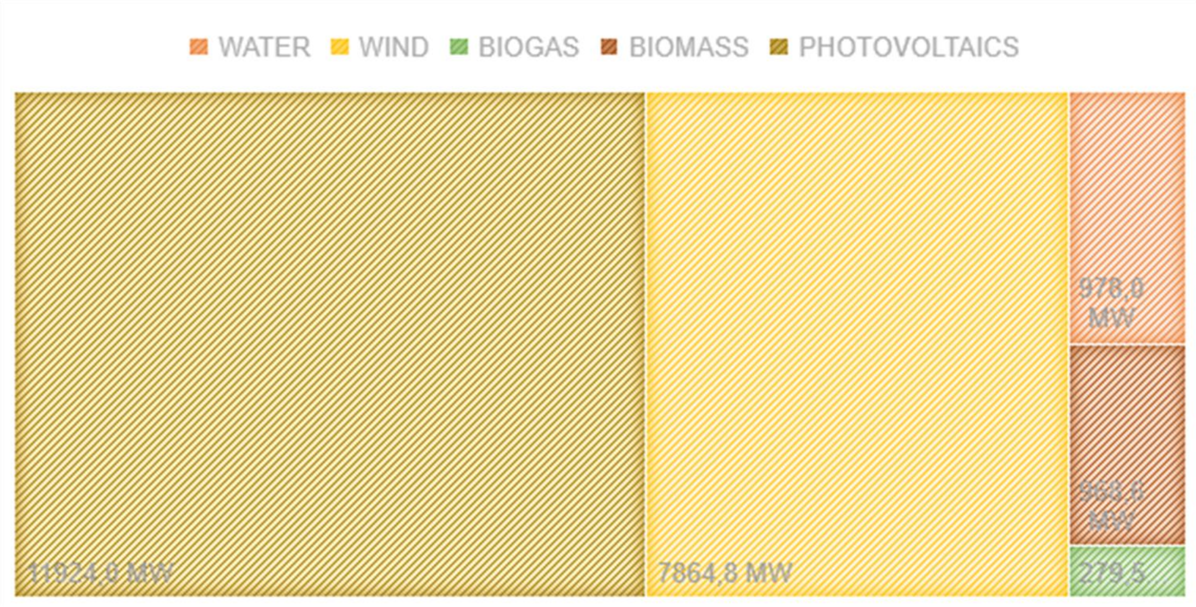

Figure 2. RES capacity structure in November 2022, in Poland.

Source: Own elaboration based on: Rynek Elektryczny (2022). Moc zainstalowana OZE wzrosła do ponad 22 GW. https://www.rynekelektryczny.pl/moc-zainstalowana-oze-w-polsce/, 4.03.2023.

In November 2022, Poland had established 12,893 renewable energy power plants, amassing 227.33 MW of total capacity. The vast majority of these are photovoltaic facilities (12,886), with a capacity of 199.2 MW; the remainder are five biogas power plants (1.87 MW) and two wind turbines (26.25 MW). No hydroelectric or biomass power plants were constructed. Overall, during the entire year of 2022, 343,700 new renewable energy sources were set up in Poland, with an installed capacity of 4.4GW. This data reveals an uneven development of renewable energy in Poland. This may be due to, among others: from: many challenges identified already at the stage of the investment process. So far, no material has been identified in the literature presenting the risks associated with investments in renewable energy sources in a comprehensive approach, where such risks would be identified at each stage of the above-mentioned process (Bajor, 2016; Michalak, 2014; Seroka, 2020, 2021b; Śpiewak, Wesołowska, 2016, 2019; Śpiewak, 2017; Szczepaniak, 2013 et al.). The main goal of the article is to fill this research gap and present the results of a comprehensive risk analysis during the investment process in the renewable energy industry.

2. Theoretical background and methodology

Comprehensive risk identification is a fundamental aspect of successful investments in renewable energy sources. By acknowledging and assessing the diverse range of risks associated with each phase of a project, stakeholders can develop effective risk management strategies and make informed decisions to achieve their sustainability and financial goals.

It is imperative for investors, project developers, and policymakers to continuously monitor and adapt their risk identification processes to navigate the evolving landscape of renewable energy investments.

In order to acquire useful information and factual data, it is necessary to use proper techniques and methods to obtain them. The degree of precision of the objectives and the materials gathered for research will determine which techniques and approaches will be employed (Jaroszewska-Brudnicka et al., 2021). As the research issue is complex, the triangulation method of research was employed. This method works by using multiple techniques to verify the results garnered from the research. A. Lewis iterative triangulation was chosen as the method of research (Lewis, 1998). This method is based on a systematic iterative process between literature exploration, empirical evidence, and intuition. Due to the nature of economic and social phenomena, research methods must be adjusted to meet the needs of the research goal. Two main research philosophies were used to define the phenomena: hermeneutics and positivism. Logic was the method of research philosophy utilized, which puts its attention on the dominant and alternative paradigms. In the realm of the dominant paradigms, quantitative methods were selected and expressed through deductive methods based on non-participant observation, analysis and synthesis. For alternatives, a qualitative approach was taken, from which literary analysis were chosen.

Non-participant observation means that the researcher is among the group of people being observed, but is limited only to a passive observation of their behavior.

3. Specificity of the analyzed issue

No signs point to the renewable energy investment process ending anytime soon. Renewable energy sources are becoming increasingly popular, meaning the investments is likely to continue. This process is usually divided into three main parts: pre-investment, implementation, and operation (Figure 3). Depending on the type of renewable energy, these stages could be different. For example, constructing a photovoltaic park may require different steps than setting up a biogas plant, which is a much more complicated process.

<table>
<tr><th>PHASES</th><th>STAGES</th></tr>
<tr><td rowspan="3">PRE-INVESTMENT PHASE</td><td>Analytical stage</td></tr>
<tr><td>Preparatory stage</td></tr>
<tr><td>Legal – administrative stage</td></tr>
<tr><td rowspan="3">IMPLEMENTATION PHASE</td><td>Financing stage</td></tr>
<tr><td>Executive stage</td></tr>
<tr><td>Generating unit operation stage</td></tr>
<tr><td>OPERATIONAL PHASE</td><td>Investment operation stage</td></tr>
</table>

Figure 3. Phases and stages in investment process.

Source: Own study.

Nonetheless, the job of honing in on the enhancement and advancement of the electricity system foundation is much easier. Guidelines in this field have been static for some time. They gave their sentiments on formal and legal, ecological and socio-economic prerequisites and on the licenses given. In this subject as well, strategic issues present no difficulties due to the accessibility of proper specialized offices. That expels all difficulties related with acquiring land and getting site licenses if the venture cycle doesn't mean to extend the office area. When investing in renewable energy sources, there are several risk factors to consider, including capital intensity, long-term returns, site constraints, grid connection requirements, reliance on national laws, and exposure to energy price fluctuations. Furthermore, the liberalization and deregulation of energy markets, along with the restructuring process and its associated uncertainties, have made it more difficult to assess the level of risk. In addition, the lack of credit guarantees and direct state aid, as well as the increasing entry of various participants into the energy market, pose additional challenges. Moreover, the availability of transmission grid capacity and the need to maintain business continuity are also potential issues. On top of that, there are also administrative, legal, and infrastructural obstacles that hinder the development of renewable energy. These include highly complex administrative procedures, a lack of stability in the legal environment, political influence, opinions of different social environments and interest groups, and infrastructural constraints in terms of possibilities to connect systems. Moreover, investments in renewable energy are still associated with relatively high levels of innovation, and new tech subjects in this area often have “teething trouble”. Furthermore, specific area resources, such as saturation of the power system causing balance problems, the location of nature reserves and details of the local landscape, and the presence of archaeological sites, can also have a significant impact on the risk. Additionally, some of the known risks can be placed in various categories, which may make them of secondary importance. Still, risk classification can be beneficial. If conducted on a regular basis, it can help in choosing the right tools to reduce or eliminate the risks. Additionally, if the risks are categorized in relation to the company's goals, it can bring more value to the investors. This could have a positive effect on the main areas of investor activity and potentially prevent or mitigate these risks (Keller et al., 2022).

4. Results

As technology progresses, people's understanding of the uncertain and dangerous world increases. Science has long since demonstrated that there are no fixed and immutable rules in the universe. Therefore, taking risks is an integral part of any transformation. Risk is an essential part of the natural environment surrounding us. Any creative human activity involves a measure of uncertainty and risk. Risk taking can be classified into various categories. Investment risk is the tolerance for the potential of achieving a different result than was anticipated when initiating a particular action. Because the future is unpredictable, investors must use forecasts and common sense when deciding on investment strategies, knowing that risk must be taken into consideration. Data obtained from various sources can lead to discrepancies between the expected and actual outcomes. Risk and volatility are intertwined. Even if the probability of certain events can be estimated, there is no guarantee that the outcomes will be evenly balanced. The RES investment process consists of several stages. Each of these stages involves distinct activities, participants and capital investments. During each phase, major risks must be identified and assessed. Having a firm grasp of the threats and their context can be helpful in making decisions.

THE PRE-INVESTMENT PHASE includes conceptual, preparatory, legal and administrative stages.

Analytical stage - includes risk areas such as site selection and site investigation, energy resource assessment, environmental impact and social conditions.

When choosing a location and studying an area, the biggest threats are figuring out who has the title to the land, confirming the legal standing of the land, accurately ascertaining what the land will be used for, recognizing energy and natural material reserves, abidance by the distance criterion, and considering the mutual effect criterion. These boundaries must be both economically advantageous and in accordance with the environment. Minor risks may involve local governments' decision-making authority, processes, terrain, and requirements concerning archaeological, geological, and geotechnical research.

When looking into energy sources, there is always a chance that the resources available in the local area may not be sufficient - such as wind, solar, water, and thermal energy, or that the necessary raw materials may be in short supply. Other possible risks include fluctuations in the cost of raw materials and changes in the manufacturing abilities of potential suppliers. Finally, it is important to pay attention to the possibility of environmental regulations altering terminal operations, or changes in the type of farms in the area.

When conducting an Environmental Impact Assessment, it is essential to evaluate the primary potential hazards associated with the development. Modifications due to environmental regulations are not substantial. Possible risks can manifest from technological advances or the scope of presumable operational settings of a facility. When analyzing social conditions, the most significant risk is social deliberation (particularly the absence of local community backing for such endeavors). There may be objections as well. Social components concerning adjustments in inhabitants' living conditions are less significant. There are also dangers associated with negotiations with local government, local community formation activities or bureaucratic processes.

Preparatory phase – focus on risk areas identification, including planning, design, infrastructure, logistics, choice of investment implementation method, and investor's decision to implement the project.

When creating a plan, the most significant risks come from potential mistakes. This can include overlooking certain aspects, miscalculating costs, and mismanaging the process while in the preparation stage. Moderate risks involve the execution of long-term planning, the usage of specialist advice and evaluation, and spotting discrepancies between expectations and ultimate results. Even less serious risks, such as climate change and other natural disasters, still need to be taken into account.

When it comes to design, the greatest danger is making incorrect suppositions. These can incorporate wrong decision of innovation and contrasts between industrial facility limit and arranged yield. Not modifying tasks as required can likewise have expensive outcomes. There might be no access street, no partition from different structures, no association with the lattice, and no inward electrical foundation, which should all be modified later. Normal hazard is identified with venture quality. Absence of clear and justifiable prerequisites, delayed endorsement forms, late progressions, misconstruing of particulars or delicate archives can cause time gauges to surpass as far as timetables and spending plans. The least recognizable hazard is getting grants and development grants.

In infrastructure, the most serious threat is that it is correctly planned for weather, design, legal, supply and implementation. Risks in infrastructure building can also be identified from the point of view of land availability, for example sound geological conditions, the state of the public road network or the construction of access and provisional internal roads. It is also crucial to collaborate with the national electricity system in terms of the distance from the operator's main feed point or the capacity of the installed transformer. Risk is also impacted by line electricity capacity, documentation of link conditions, and lack of assurance of connection to the mains.

Other risk factors that can affect the success of a project include the state of the connecting infrastructure (particularly external), the condition of the property (due to contamination, pollution or hydrological issues), and the absence of sufficient cost controls. It is also important to make sure that tasks, purchases, and deliveries are carried out in a timely manner. The design documentation and the quality of the work must also be taken into consideration. Social issues are amongst the least risky factors. There is the potential for social resistance to the project due to the disruptions caused by the construction, as well as difficulties in recruiting skilled labour, and any surprises such as archaeological finds, unexploded ordnance, changes in regulations etc.

When it comes to logistics, major risks may involve accidents, destruction of machinery, inadequate capital flow, inaccurate information, and tardy deliveries (Jezierski et al., 2021). Moderate risks may include inadequate protection of the conveyance of the generator set, not picking the best route, substandard quality of delivered components (semi-manufactured goods), orders that are not in sync, and cash that subcontractors providing such services may not have enough of. Lower risks might center around entrance conditions, safeguarding and storage of supplies, access to equipment and its efficacy when utilized, and keeping track of its performance.

The riskiest decision when it comes to investing is the selection of the general contractor or contractor to work on the project. If the wrong choice is made, the project could be delayed or not completed as planned. Additionally, if the investor and the contractor do not get along, the project could suffer due to miscommunication and disagreements. The risks also extend to the selection of substitute investors or contract managers, as the wrong choice could result in the same problems. Poor cooperation between the investor and their chosen company can result in average risk, while lesser risks include lack of understanding or disgruntled workers (Przybył et al., 2017).

When assessing a potential project, the biggest peril is correctly recognizing the kind of risk involved. Although not as significant, it is still vital to determine and observe the scheduled commencement and termination times, technology picks and financing approaches. The least risky element of this is the selection of the personnel, as their decisions can make or break the project.

Legal-administrative stage – focus on differentiates risk areas such as acquisition of land rights, environmental condition determination, development condition determination, institutional investment permits and grid connection permits.

When acquiring property, it is important to consider who owns the land. Investment in energy technology carries a greater risk of buying it back at a higher price than the market rate. Less crucial matters include matters regarding the conveyance of rights, additional fees, conflicts with the owners, etc. Occupancy and lease issues pose the least risk. Issues regarding rent payments or difficulty of access to the land are primary concerns.

The risks associated with the determination of environmental conditions were identified, including the potential for prolonging the process, stopping investment, or clashing with parts of the local community. Additionally, the assessment may require adjustments or new restrictions to be implemented, and the conclusion of the assessment may require the original decision to be rewritten.

When it comes to building permits, the municipality's process for deciding on them and how the area should be developed is fraught with the greatest danger. For licenses, a moderate risk is present. The least risky choice is to carry out engineering projects to fulfill development demands (Willumsen et al., 2019).

When applying for an investment permit, the most hazardous part is acquiring a building permit under the Construction Act. Officials must be aware of the legal information in order to ensure that no pressure is given to pass laws that are too stringent, maintain loopholes in the legal acts, or incorrectly interpret the existing laws. Having the proper construction project is required in order to receive a building permit and is less risky. It is important for policy makers and officials to have good legal knowledge to avoid the potential abuse of power. The least risky situation is getting a permit for ancillary facilities, but unpredictability in the way officials interpret the relevant rules may still be a problem.

When applying for a grid connection permit, there is a risk of legal changes that could delay the release of the connection conditions, which are necessary to begin planning, constructing, and assembling. To reduce this risk, it is advisable to acquire assignment easements and easements, which are essential documents accompanying the connection conditions and building permits (Śpiewak, Wesołowska, 2019).

THE IMPLEMENTATION STAGE includes financing stage, implementation stage and unit operation stage.

Financing Stages – focus on risks which are created through activities such as cost control, economic and technical solution optimization, financial engineering and forms of financing or insurance at each stage.

The greatest risk in relation to capital and operating costs exceeding the estimated budget is the need for cost containment at all stages of the investment. In addition, tax variance can be a significant source of risk, as incorrect assumptions, changes in taxation, varying interest rates, exchange rate fluctuations, inflation adjustments and other factors may reduce the ability to successfully refinance investments and thus reduce profitability. A further risk is the possibility of a difference in the salvage value due to initial charges that were not taken into account when the analysis was made and differences in the actual and estimated costs. Lastly, there is the risk of the investment losing value once it is completed.

The optimization of economic and technical solutions requires the management of risks associated with over-investment or under-investment. The key factor in this process is controlling the efficiency factor (which is what determines the cost-benefit ratio). This includes costs for upkeep (materials, personnel, etc.), operational costs, the machinery and its dependability and quality, as well as the chosen energy production technology. Moderate risk is associated with the lack of cost control, late delivery, contractual fines, choosing auxiliary equipment and their compatibility, which will affect the efficiency. The energy sector in Poland is a heavily regulated industry, so prices can be set as "hard" (too high or too low), which also carries risks (Viskuba et al., 2021).

The application of financial engineering carries the most significant hazards when it comes to gauging the economic value of projects, particularly in regards to the utilization of operating and financial leverage. A lower-stakes hazard zone is the development of economic studies and the accuracy of the assumptions therein. In terms of the long-term operation of technical facilities, the least risk is linked to the precise measurement of energy resources. Choosing the form of financing is key to recognizing the areas with the greatest investment and financing risks. This is where debt and equity financing come into play. It enables the project to get off the ground and continue as intended. Dangers in this zone generally stem from the effective acquisition and management of funds, which can lead to the repayment of grants from EU schemes or regional funds. The average risk in this domain is revealed by changes in financing conditions, i.e. loan interest, margin or equity ratios. Smaller but still possible other hazards within this group involve alterations in the likelihood of access to aid programs and public subsidies.

The selection of insurance involves potential threats, such as actual premiums rising higher than anticipated in the bidding process. The middle risk level encompasses the potential for modifications in the insurance market due to mergers or bankruptcies. Low risk involves the inability to protect against unanticipated situations or calamities arising from natural disasters.

Executive stage – describes risk areas such as staffing and training, detailed engineering design, contractor search and selection, negotiation and procurement and supply agreements, civil works and equipment installation, and commissioning.

The greatest danger of incorrectly assigning tasks is inadequate staffing and training programs. There is a strong possibility of recruiting inadequately skilled personnel and selecting the wrong incentives. Another problem is the absence of clear testing standards in the recruitment and selection process and the lack of resources for personnel development. There is also a low to moderate risk of restructuring and redundancies, as well as interpersonal conflicts. Finally, there is a small, but real, risk of these issues (Shimbar et al., 2020).

The main risk associated with the preparation of the detailed technical design is not meeting the legal requirements of the Ministerial Decree of 2 September 2004 (in the Journal of Laws of 2004, No. 202, item 2072). Lesser risks include errors in estimates, quotations, equipment and material. Additionally, there is a risk that the necessary agency approvals may not be obtained.

Finding the right contractor involves assessing a range of risks, such as a lack of clear criteria for selecting contractors, inadequate contracts, and an insufficient understanding of the financial standing of the investor partnership. Additionally, it is important to ensure the contractor holds the appropriate licences for the job and, ultimately, to establish the contractor's trustworthiness.

Outsourcing services from firms operating in the informal economy carries the least amount of risk, followed by the potential for non-compliance with the terms of a contract or agreement. At the medium-level risk is the potential for errors or formalities in the tendering process to render the whole process obsolete. Finally, the lowest risk can be found in poorly worded tender documents.

The greatest risk associated with the construction and installation of equipment lies in the condition and accessibility of the investment site. In order to reduce this risk, it is essential to have perfect design documentation and the appropriate adjustment of infrastructure elements. Additionally, the risk is increased by inexperienced workers, poor quality of work, changing requirements during the works, time and budget overruns, and the financial status of the inwestor (Okręglicka, 2022).

A medium level of risk is associated with staff shortages, technological issues, interruptions in the constant supply of building materials, and also malfunctioning or contaminated supplies. Other risks may include strikes due to personnel shortages, overestimation of results, problems with subcontractors, issues with the collaboration of involved parties, competence conflicts, and accidents and their impacts. The smallest risk identified is that of complications in cooperation.

The implementation of the test run carries with it the greatest risk of incompatibility between the infrastructure elements and the solutions used, which could lead to an inability to obtain an occupancy permit. There is moderate risk related to any regulatory ambiguities surrounding the trial run, and the smallest risk lies in the potential for "acts of God" or fortuitous events, such as extreme weather, natural disasters, contractual breaches, and strikes, which could cause delays and stoppages (Maciejowska, 2022).

Generating unit use phase – risk areas, such as commissioning and commissioning, management of the generating unit, obtaining a license to generate energy, energy sales contracts and optimization of the production process.

The greatest risk lies in obtaining approval and permission to use the completed work, verifying that all the required conditions have been fulfilled. This is also what makes payment for the work possible. Confirmation of the completeness or incompleteness of the relevant documentation is also associated with a moderate degree of risk. The least risky aspect of the task is adhering to the set timeline requirements from contractors (Wang et al., 2022).

The greatest challenge associated with running a generating unit is the requirement to continually assess and adjust performance in response to changing market conditions, legislation, and competition. Gathering data related to the operation of the power plant is also a moderate risk. Lower risks include effectively analyzing the data for regularity, periodicity, and reliability, as well as an aversion to change and move towards innovation.

The greatest risk when applying for an energy production concession is not fulfilling the demands of Polish Energy Law. Medium-risk concerns include the need to meet the demands of the many documents related to the investment (about 20). The lowest, but still present, risk is the time-consuming court proceedings due to the appeal process against the decision of the Energy Regulatory Office. Every effort should be taken to avoid having to utilize this remedy.

The conclusion of an energy sales contract carries the risk of incorrectly picking the type of contract, fluctuations in trading amounts and prices on the Polish Power Exchange, trading of "green certificates" on the stock exchange, and the potential for parties to fail to comply with the terms of the agreement.

The implementation of production process optimization has the potential to introduce errors during the design phase, reduce the dependability of production process analysis and fail to take advantage of the potential of the location. Minimizing the risk associated with this course of action involves identifying the worst-case environmental impacts and exploring the various technical and economic solutions available. Selecting the most viable option from these possible variations can help limit the risk of adverse outcomes.

THE OPERATONAL PHASE – means commonly the end of the project. It consists of the stage of investment activity.

Stage of investment activity – focuse on risk areas, created by the challenges associated with achieving the assumed efficiency, ongoing maintenance, recovery of resources, modernization and expansion, liquidation, post-consumer extension of a technical facility or land reclamation (He et al., 2019).

The chances of reaching the projected productivity can be hampered by a number of risks, such as the use of complex technology, disruption due to changing weather, the probability of failure, environmental pollution, the influence of weather on operations and malfunctioning, the chance of failure of ground equipment, and the dangers of using chemical substances (when using geothermal energy). The smallest, but still present, risk comes from unseen defects in equipment and weak foundations (Li et al., 2021).

The risks associated with emergency planning can be minimized by regularly conducting inspections and replacing inferior equipment. The lowest risk is associated with preventive maintenance of the equipment.

The process of resource recovery can carry several kinds of risks, such as the damage or destruction of infrastructure elements due to technological progress, vandalism and theft, incorrect analysis of the profitability of modernization works, purchase of incomplete equipment, defective components and modification of requirements, and low-quality services (Rød et al. 2020). As the market is becoming increasingly competitive, newer and more innovative solutions are being implemented, which can also add to the risk.

The greatest risk associated with liquidation is the prospect of having to redeem contracts and bonds on demand, and the potential for costs to exceed the expected amount. A less pressing concern is the difficulty of selling the power plant's equipment, due to a lack of interested buyers or abnormally low purchase prices. Finally, the least significant risk is related to environmental protection, as the regulations in this area are very strict, making it an unlikely source of worry.

Activities that come after the consumer use of a technical object pose the most dangerous consequences to environmental preservation due to the lack of recycling resources. On the other hand, the available recycling technology is deemed to be inexpensive and uncomplicated, reducing the risk. Additionally, the potential for reusing recovered parts has been identified as a low-risk situation.

The greatest risk associated with land reclamation is the potential for land degradation and the subsequent inability to access the area. Furthermore, soil erosion and the cost of reconstructing the land are of medium risk. Lastly, the lowest risk is the possibility of having to modify the land's direction of use due to reclamation works.

5. Discussion

This article discusses the key findings which focuses on the energy sector, particularly renewable energy sources (RES). Poland, with its rapidly growing renewable energy sector and similarities to Germany, was examined as a case study. The article emphasizes the importance of risk management in RES investments and the unique challenges posed by these investments.

Poland's commitment to reducing carbon emissions and transitioning to sustainable energy is reflected in its ambitious targets for renewable energy sources, particularly wind, solar, and biomass. The article identifies a broad spectrum of potential risks associated with RES investments, including technical, regulatory, environmental, market, operational, and social risks. It stresses that these risks are not unique to Poland and are relevant to other regions as well. Effective risk management in RES investments requires a thorough understanding of the risks, their magnitude, and their potential impact on projects. The article underscores the need for a comprehensive approach to assessing these interrelated risks. Natural disasters are an exceptional category of risks in RES investments, as they are uncontrollable and unpredictable. There is necessary to acknowledges the severity and unpredictability of disasters and their unique nature. Not all risks are equal in their impact on project completion. The article emphasizes the importance of analyzing the sources of risk and allocating resources to mitigate them, highlighting that investors often prioritize risk management in their decision-making. This section underscores that effective risk management is pivotal in the success or failure of RES investments, as these investments involve complex decision-making processes. Investors often base their decisions on the actions taken to minimize risks. Government policies and regulations play a crucial role in mitigating risks and encouraging RES investments. Consistent policies are essential to address certain risks, such as regulatory changes or market fluctuations.

The article's exploration of RES investments in Poland provides valuable insights for investors, policymakers, project developers, and all stakeholders involved in sustainable energy solutions. It underscores the central role of effective risk management in realizing the potential of renewable energy sources and achieving a cleaner, more sustainable energy future.

6. Conclusions

The article looked into the details of the energy sector, with special attention to renewable energy sources (RES). Poland, a growing nation with similar climatic conditions and RES potential as Germany, a leader in the industry, was used as an example. Subsequently, the next stages of RES investment were identified and potential risks were identified. These risks are dependent on the specific nature of investments and the degree of their impact on a given project. While most of these risks are related and intertwined, disasters are the only exception.

No matter where the sources of risk originate, the set of numbers associated with them will determine the potential for danger. Although all of these risks are important, their individual effects on the completion of the task may differ. Some risks that cannot be quantified can be more serious than those that can be measured. By analyzing the sources of risk, it is possible to determine the resources needed to reduce the likelihood of harm. Taking steps to reduce the risk associated with the investment will often be the deciding factor for investors when making their decision.

References

1. Bajor, M. (2016). Ryzyko towarzyszące inwestowaniu w odnawialne źródła energii w Polsce. *Zeszyty Naukowe Politechniki Częstochowskiej, Zarządzanie, nr 24, t. 2,* https://doi.org/10.17512/znpcz.2016.4.2.22
2. He, L., Liu, R., Zhong, Z., Wang, D., Xia, Y. (2019). Can green financial development promote renewable energy investment efficiency? A consideration of bank credit. *Renewable Energy, vol. 143,* pp. 974-984, https://doi.org/10.1016/j.renene.2019.05.059.
3. Jaroszewska-Brudnicka, R., Brudnicki, R., Śpiewak, R. (2021). Big Data Analysis – nowa, lepsza metoda badań konsumentów usług turystycznych w regionach? Analiza porównawcza na przykładzie badań ruchu turystycznego prowadzonych w regionie kujawsko-pomorskim. *Zeszyty Naukowe Wyższej Szkoły Gospodarki: Turystyka i Rekreacja, t. 37, nr 16,* https://doie.org/10.0305/ZNTiR.2023457117.
4. Jezierski, A., Mańkowski, C., Śpiewak, R. (2021). Energy Savings Analysis in Logistics of a Wind Farm Repowering Process: A Case Study. *Energies, vol. 14, no. 17,* https://doi.org/10.3390/en14175452.
5. Keller, J., Radke, M. (2022). Optimism and Risk Tendencies of Individual Investors. *Acta Universitatis Lodziesis Folia Oeconomica, vol. 4, no. 361,* https://doi.org/10.18778/0208-6018.361.04.
6. Kwinta, W. (2022). *Kto produkuje najwięcej zielonej energii na świecie? TOP 30.* https://inzynieria.com/energetyka/odnawialne_zrodla_energii/rankingi/65636,kto-produkuje-najwiecej-zielonej-energii-na-swiecie-top-30, 4.03.2023.
7. Lewis, M.W. (1998). Iterative triangulation: a theory development process using existing case studies. *Journal of Operations Management, vol. 16,* 455-469.
8. Li, M., Hamawandy, N.M., Wahid, F., Rjoub, H., Bao, Z. (2021). Renewable energy resources investment and green finance: Evidence from China. *Resources Policy, vol. 74,* https://doi.org/10.1016/j.resourpol.2021.102402.

9. Maciejowska, K. (2022). Portfolio management of a small RES utility with a structural vector autoregressive model of electricity markets in Germany. *Operations Research and Decisions, vol. 32, no. 4*, http://dx.doi.org/10.37190/ord220405.
10. Michalak, J. (2014). Ryzyko w projektach inwestycyjnych energetyki odnawialnej. *Poznan University of Technology Academic Journals. Electrical Engineering, no. 79.*
11. Okręglicka, M. (2022). Risk in the area of human resource management in micro, small and medium-sized manufacturing enterprises. *Humanitas University's Research Papers Management, 23(1)*, pp. 21-31, http://dx.doi.org/10.5604/01.3001.0015.8606.
12. Paska, J., Surma, T., Terlikowski, P., Zagrajek, K. (2020). Electricity Generation from Renewable Energy Sources in Poland as a Part of Commitment to the Polish and EU Energy Policy. *Energies, vol. 13, no. 16*, https://doi.org/10.3390/en13164261.
13. Przybył, M.A., Śpiewak, R. (2017). Influence of regulator on financial factors of the electricity distribution system operators. *Polityka Energetyczna – Energy Policy Journal, 20(2)*, pp. 89-104.
14. Rød, B., Lange, D., Theocharidou, M., Pursiainen, C. (2020). From Risk Management to Resilience Management in Critical Infrastructure. *Journal of Management in Engineering, vol. 36, no. 4.*
15. Rynek Elektryczny (2022). *Moc zainstalowana OZE wzrosła do ponad 22 GW.* https://www.rynekelektryczny.pl/moc-zainstalowana-oze-w-polsce/, 4.03.2023.
16. Seroka, A. (2020). Plany inwestycyjne w OZE szansą na zrównoważony rozwój w województwie pomorskim. *Przestrzeń, Ekonomia, Społeczeństwo, nr 17/1*.
17. Seroka, A. (2021a). Znaczenie odnawialnych źródeł energii w krajowym systemie energetycznym. *Zeszyty Studenckie „Nasze Studia”, nr 11*, https://czasopisma.bg.ug.edu.pl/index.php/naszestudia/article/view/6027
18. Seroka, A. (2021b). Identyfikacja mikro- i makroekonomicznych ryzyk inwestowania w ekologiczne źródła energii elektrycznej. *Nauki Ekonomiczne, tom XXXIII*, https://doi.org/10.19251/ne/2021.33(10).
19. Shimbar, A., Ebrahimi, S.B. (2020). Political risk and valuation of renewable energy investments in developing countries. *Renewable Energy, vol. 145*, https://doi.org/10.1016/j.renene.2019.06.055.
20. Sowiński, J. (2012). Niepewność cen i kosztów technologii wytwarzania energii elektrycznej w analizach projektów inwestycyjnych. *Polityka energetyczna, Tom 15, Zeszyt 3.*
21. Szczepaniak, K. (2013), Finansowanie inwestycji w energetykę odnawialną i poprawę efektywności energetycznej - atrakcyjność, ryzyko, bariery. *Prace Naukowe Wyższej Szkoły Bankowej w Gdańsku. System finansowy: aktualne wyzwania i perspektywy rozwoju, Nr 27.*

22. Śpiewak, R., Wesołowska, P.A. (2016). Types of risks in the process of investing in renewable electric energy sources. *Acta Energetica, 4/29,* https://doi.org/10.12736/issn.2300-3022.2016410.
23. Śpiewak, R. (2017). Mikroekonomiczne ujęcie analizy ryzyka inwestowania w alternatywne źródła wytwarzania energii elektrycznej. *Zeszyty Studenckie „Nasze Studia", nr 8,* https://czasopisma.bg.ug.edu.pl/index.php/naszestudia/article/view/3433
24. Śpiewak, R., Wesołowska, P.A. (2019). Makroekonomiczne aspekty oceny ryzyka inwestowania w innowacyjne źródła wytwórcze energii elektrycznej. *Zeszyty Studenckie „Nasze Studia", nr 9,* https://czasopisma.bg.ug.edu.pl/index.php/naszestudia/article/view/3394.
25. Viskuba, K., Silinevicha, V. (2021). Renewable Energy Sources in the Baltic States and New Business Approach of the Sector. *Vilnius University Open Series,* https://doi.org/10.15388/VGISC.2021.16.
26. Wang, Q., Dong, Z., Li, R., Wang, L. (2022). Renewable energy and economic growth: New insight from country risks. *Energy, vol. 238, part C,* https://doi.org/10.1016/j.energy.2021.122018.
27. Willumsen, P., Oehmen, J., Stingl, V., Geraldi, J. (2019). Value creation through project risk management. *International Journal of Project Management, vol. 37, no. 5,* https://doi.org/10.1016/j.ijproman.2019.01.007.