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Strategic Assessment of the Environmental Impact of Ski Resorts as Part of the Polish Energy Policy Project

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Abstract: The dilemma of choosing between conventional energy and renewable energy sources is a topic of discussion in various economic and social sectors. This problem is not only a matter of the country's energy security but is also an important element of sustainable development that affects the functioning of future generations. The analysis of this process must cover all aspects of operation, with particular emphasis on tourism, including ski resorts. The aim of the work is to assess the current state of ski infrastructure in terms of the possibility of using green energy to power these types of devices, with an indication of the profitability of implementing this project. This analysis will cover the types of renewable energy sources and how they are used in winter sports resorts around the world, whilst additionally focusing on the energy structure of Poland and the European Union, as well as on energy transformation plans in Poland. An important aspect of this analysis is to understand the barriers to the development of the unconventional energy sector and the ski resorts themselves. The impact of ski resorts on the natural environment was also examined. When analyzing the profitability of introducing green energy to power ski slopes, the costs of traditional energy sources in a Polish ski resort were analyzed. The benefits of introducing green energy were indicated by comparing SWOT analyses of the Polish coal sector with renewable energy sources. In the economic context, the profitability of the proposed renewable energy installation was presented, using the NPV, IRR and payback period methods. The analysis of the cost structure of traditional energy sources allowed for the identification of a potential investment in renewable energy technologies, showing the share of electricity costs in the structure of energy carriers used on the ski slope. As a result, the profitability of the installation project was indicated as photovoltaic with specific power and parameters. Although the presented considerations refer to the realities and legal regulations applicable in one of the selected European Union countries—Poland, a country where energy from photovoltaic panels is developing the fastest among all renewable energy sectors in Europe—these considerations can be used in practice to indicate further directions and development prospects for other regions of the world. At the same time, the content of the considerations creates the basis for further development of research on these processes in order to popularize Poland's energy policy.

Keywords: energy transformation; renewable energy sources; green energy; ski resorts; SWOT analysis; economic efficiency

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1. Introduction

The dilemma between conventional energy and renewable energy is a topic of discussion in various economic and social sectors. It is not only a matter of the country's energy security but it is also a key element of sustainable development, affecting the functioning of future generations. Poland, being an EU Member State, is obliged to carry out a comprehensive energy transformation, the aim of which is to reduce the emission of harmful substances into the atmosphere and to increase the share of green energy in the country's energy structure. The analysis of this process must cover all aspects of operation, including the tourism industry, with particular emphasis on winter sports and ski resorts. Although environmental protection and the exploitation of mountainous areas are often discussed, they are rarely analyzed in the context of energy and structural changes.

To understand the potential for change in the sector, it is necessary to focus on unconventional energy opportunities, the impact on the environment and the benefits of changes in the energy sector. Examples from other countries where renewable energy technologies were used in the area of winter sports show the potential of using solar, wind, geothermal and hydropower energy. This approach allows for not only a reduction of the negative impact on the environment but also for a reduction in the costs of winter tourism and for achieving energy independence. In the context of the EU's commitments regarding climate neutrality by 2050, it is necessary to analyze Poland's current energy structure, commitments and strategies that have been adopted to achieve the transformation by 2030. It is also worth considering the challenges the country must face to ensure development opportunities for future generations.

The research defined barriers related to renewable energy and the operation of ski resorts, taking into account the impact of law, society, administration and changing weather conditions. The research also assessed the impact of this industry on the ecosystem, changes in the forest structure, internal migrations of fauna, the effects of artificial snowmaking and the threats related to the development of ski infrastructure. The environmental research performed allows for the identification of costs related to the share of traditional energy sources in ski resorts and their impact on the environment, including greenhouse gas emissions. The benefits and costs of installing renewable energy sources presented by the authors and the profitability analysis of such a project are important for understanding potential transformations. Ultimately, the work aims to provide a comprehensive analysis that forms the basis for decisions by both representatives of the ski sector and political decision-makers about the possibilities of using green energy to power these types of devices, with an indication of the profitability of implementing this project. Achieving the goal of the work required the following tasks:

- identification of key aspects related to ski infrastructure,
- assessment of the impact of ski resorts, renewable energy and conventional energy on the natural environment,
- analysis of development barriers of ski resorts along with the expectations of their users,
- conducting a field study to analyze the costs of traditional energy in the winter tourism sector,
- identification of the limitations of the renewable energy sector in Poland,
- analysis of the possibilities of implementing green energy in the area of ski resorts,
- SWOT analysis of the renewable energy sector,
- developing a profitable plan to introduce solar energy into the energy structure of ski resorts.

The implementation of the presented tasks will allow the development of a model for the implementation of renewable energy sources in the energy structure of ski resorts, which are an element of Poland's energy transformation.

The article is divided into the following sections. Section 2 contains a review of the global and national literature on the environmental impacts of ski resorts as part of the management of Poland's energy transition. Section 3 describes the research methodology used to analyze the profitability of green energy in ski resorts. Section 4 contains the results of research and experiments as well as extensive commentary on them. Section 5 presents the research conclusions and prospects for further development.

2. Literature Review of the Problem

2.1. The Essence of the Research Problem

The concept of energy transformation refers to global changes in the energy sector and is directly related to the concept of sustainable development. Sustainable development is the preservation of the current development of the world, which at the same time does not constitute development limitations for future generations. This concept can be interpreted as a series of changes enabling the current and each subsequent generation to function to a similar extent, a series of boundaries and changes necessary to preserve the planet's resources and the natural environment for future generations in every branch of human utility, including mountain tourism.

Analysis of the impact of ski resorts on the natural environment in the context of Poland's energy transformation is an extensive issue. The literature review highlights key elements that are necessary to understand the overall environmental impact of winter tourism, including changes in the energy structure. A particularly important area of research is the green sector energy, which is a fundamental element of changes in EU member states. Available methods of generating electricity from unconventional sources and their impact on the natural environment should be analyzed. These issues are extensively presented in the literature [1–27]. The accumulated knowledge, combined with the illustration of specific cases of the use of renewable energy in ski resorts, constitutes the basis for changes in this sector. Green energy solutions and technologies in winter resorts are not commonly discussed in scientific publications. The country's energy transformation is a complex concept, subject to changing legal regulations and entities' strategies. An important aspect of the analysis is to determine the impact of the entity and factors affecting the environment [28–34]. Tourist traffic and related competition are key factors in the development of ski slopes.

Growing interest in winter sports as an alternative to spending time in the winter season, forces the creation, expansion and introduction of new technologies into ski infrastructure in mountain areas. In addition to the conditions necessary for practicing sports, the entire tourist infrastructure is being created in the form of a catering network, accommodation, parking zones and many others [35]. A ski resort is a place with infrastructure enabling winter sports, such as slopes, cable cars and ski lifts. For the proper functioning of tourism, an extensive lighting and electricity network as well as technologies for storing water, snowmaking, collecting and distributing snow are needed. In 2022, there were approximately 180 centers operating in Poland, due to the creation of new projects as well as the modernization and expansion of existing facilities [36]. Ski resorts are associated primarily with winter recreation but most of them also operate in the summer season in the form of bicycle and hiking trails and mountainous areas. These places are also the center of cultural events such as sports competitions, concerts, festivals and initiatives such as outdoor cinema. Increased tourist traffic is a driving force for further development of the economy and infrastructure in the region [37].

It is important to emphasize that the development of renewable energy sources will probably be concentrated in places far from the largest centers of demand for electricity, such as ski resorts. This scheme of action is also in line with the goals of energy transformation in Poland by striving to save energy and improve energy efficiency and zero carbon dioxide emissions, i.e., a key requirement in achieving climate neutrality by 2050. The growing role of renewable energy sources in ski resorts also implies significant socio-economic changes at the local level, while supporting the idea of sustainable development.

2.2. Literature Review of the Analyzed Problem

Ski resorts need significant amounts of energy to prepare their infrastructure for the winter season and maintain the entire complex in proper condition. The growing demand for electricity, its price and the ecological awareness spreading among people over the years are also reflected in ski resorts. There are many centers that take action to save energy, produce it from renewable energy sources and minimize the impact on the environment. The Flims Laax Falera ski resort is located in Switzerland and has a total of 224 km of ski slopes. The center's goal is to achieve complete self-sufficiency and cover 100% of the energy demand from renewable energy sources of local origin. To step closer to this goal, a six-point plan was implemented. It involves expanding the infrastructure using climate-friendly materials and replacing existing oil heating systems. A large contribution to achieving the goal chosen by the company is through the construction of a positive energy balance and the installation of photovoltaic panels on the buildings. For the proper functioning of ski tourism in the resort, 280 GWh is needed. By modernizing buildings and transport, the company estimates that the reduction in energy losses may be as much as 110 GWh less than the current demand. Currently, almost 70 GWh is obtained from unconventional energy sources. The usability of the area is estimated at 290 GWh, of which over 30% may come from hydropower, 55% from photovoltaics, 10% from biomass and the remaining 10 GWh from wind farms. Tourists visiting the resort also have a significant impact on the environment. Flims Laax encourages people to walk, cycle and abandon combustion vehicles by expanding the infrastructure for charging electric vehicles. To achieve energy goals, wind energy, hydropower and photovoltaics and their accompanying technologies are to be used for energy storage. In addition to energy changes, the center also teaches tourists about respect and protection of nature and biodiversity, by preventing litter and keeping the environment clean as part of a circular economy [38]. The Silvretta Arena ski area located in Ischgl, Austria, consists of 239 km of slopes and is a climate-neutral region. In addition to tree plantations in nearby forests to compensate for CO_2 emissions, it plans to introduce new technologies that will reduce fuel consumption in snow groomers and hybrid models by 20%. Geothermal energy is used to heat some buildings, thus completely eliminating fossil fuels [39]. All ski lifts are powered almost entirely by renewable energy, mainly from hydroelectric power plants. In addition, photovoltaic systems and heat recovery systems in the region will save approximately 80,000 dm^3 of fuel oil. To reduce energy consumption, artificial snow production uses satellite technology to measure snow depth [40]. Another ski area, Zermatt, is located in Switzerland and consists of a total of 200 km of ski slopes. The area itself is free from car traffic, offering bicycles, electric buses and electric vehicles created on-site instead. Environmental construction supervision was introduced and the fuel used in snow groomers was replaced with sulfur-free diesel oil, which reduces CO_2 emissions [41]. In order to increase the share of energy obtained from renewable energy sources, almost 700 solar panels were installed, which produce 212 MWh of energy annually. Additionally, there is the Grande Dixence dam in the area, which collects water from the surrounding glaciers. It allows for annual energy production of 2 TWh [42]. The La Plagne and the Paradiski region, with 225 km of slopes and 98 lifts, rely on sustainable energy production. The central point is a biomass power plant providing 90% of the energy needed for the entire facility's urban infrastructure [43]. The full fleet of vehicles available at the center consists exclusively of electric cars. To reduce the impact on the environment, no chemicals are added to the water in the artificial snow production process, and the liquid needed for this process is obtained from a tank that is filled spontaneously by the seasonal melting of the snow cover and atmospheric precipitation [44]. Snow groomers used to spread snow are equipped with sonar that measures the depth of snow cover. The machines are powered by ecological, degradable oil. To minimize the impact on animal and plant habitats, some slopes are deprived of mechanical snow distribution by snow groomers, and the snow cover is left intact [45]. Jiminy Peak, located in Massachusetts, United States, operates on the principles of conserving land and energy, protecting forest and wildlife habitats, and maintaining water quality. In 2007, the center began generating wind energy using a turbine called Zephyr [46]. A 1.5 MW turbine covers 33% of the electricity demand per year. In the winter season, when the wind is stronger, the turbine can cover up to 50% of the demand. The annual amount of energy produced is 4.6 GWh, which is the equivalent of over 3500 t of CO_2. To save electricity during the snow-making process, the cannons were replaced with new technologies that ensure a 100% increase in snow production while using less compressed air. Additionally, a reservoir with a capacity of over 22 million dm^3 of water was built to collect water from the stream only during periods of high flow and then store it for use during periods of low flow [47]. On almost 50,000 m^2 of the center's area, there is a 2.3 MW photovoltaic installation owned by Nexamp. This company sells energy credits to its partners, including the ski resort under review, to compensate for energy expenses [48]. The Wolf Creek ski resort located in Colorado uses only renewable energy to operate, from operating elevators to electricity for buildings. Initially, from 2006, the center used energy obtained from unconventional sources purchased from an external supplier, obtained from solar radiation, wind and hydropower. Since 2017, the center has been powered by solar energy, the main energy source of which is the local Penitente Solar Project in the San Luis Valley with a capacity of 2.75 MW. The power plant can produce 7 MWh of solar energy per year, of which Wolf Creek's demand is 1 MWh [49]. The center uses 100% biodegradable hydraulic oils in its vehicles, and in the summer of 2021, they built an electric vehicle charging station on site.

The use of renewable energy in ski resorts is not a new phenomenon. Over the years, some centers have made steps towards green energy, but few of them rely entirely on unconventional energy. Despite the difficulties associated with the general development of renewable energy and the challenges of the winter sports industry, renewable technologies have been implemented around the world. Solar, wind and water energy dominate, but geothermal energy or biomass distribution can also be observed. Despite the lack of one universal solution, the development of renewable energy technologies is an opportunity for each ski resort. Factors such as the amount of energy purchased, climate change and the growing belief among the population of the need to care for the natural environment contributed to the energy transformation in the structure of the institutions presented above [50]. Due to the specificity of their activities, ski resorts are particularly susceptible to high costs related to energy. Changing the energy structure provides protection against rising public service and operational costs. Energy expenses are usually the second largest amount of all costs incurred, accounting for 10–30% of the budget. Depending on the size of the slope, infrastructure and the country, daily operating costs can amount to up to USD 40,000 [51]. To produce 1 m^3 of snow, 1–14 kWh of electricity is needed. Weather conditions during the winter season in the mountain region contribute to energy supply problems, which may take many hours to resolve due to the location of the slopes. The solution to this problem may be investment in renewable energy and energy storage by centers. Environmental and natural landscape protection programs constitute an independent promotion and encourage tourists to visit the slopes again. The costs of implementing photovoltaics vary depending on the country; however, solar energy is characterized by a payback period of 5–10 years [52]. With limited space in ski resorts, rainfall and snow accumulation, sun tracking technology can be used to maximize energy production. Thanks to constant technological progress, wind energy is one of the cheapest sources of energy available. The application of wind technologies depends entirely on wind speed. To make the ski infrastructure energy independent, a small-scale wind farm and a few turbines are enough. The terrain conditions also allow for the implementation of hydropower in the form of run-of-river and reservoir power plants. The use of water technology in ski resorts will depend on the available water resources in the area. Most ski resorts may feel the consequences of climate change in the future. Therefore, it is crucial to implement renewable energy into the winter sports industry to reduce human impact on the environment. When climate change begins to have a major impact on resorts, unconventional energy will become a key element to the survival of winter tourism.

2.3. Barriers to the Development of Renewable Energy in Poland in Ski Resorts

In addition to the barriers related to the ski industry itself, attention should be paid to the limitations to the development of renewable energy in Poland. They constitute an obstacle during the energy transformation and in Poland's achievement of the EU requirements. The conventional energy infrastructure developed over the years, accompanied by large financial resources, constitutes a barrier to the dynamic expansion of renewable energy sources. The perspective of using green energy in the energy industry is determined by factors such as technical, market, political, economic, social and implementation aspects [53]. Technological limitations are currently not the dominant barrier to development in Poland and in the world. Institutional and political obstacles include the inappropriate construction of legal acts, bureaucracy problems related to the lack of knowledge about the specificity of renewable energy, its impact on individual sectors, the procedural nature of institutions and investment problems [54]. An example of a legal act constituting a barrier is the act on investments in wind farms. Rule 10H stipulates that the minimum distance of new wind energy investments from urban development and forms of nature protection is ten times the height of wind farms. The introduction of the act contributed to slowing down the development of wind energy in Poland and excluded the possibility of many investments [19].

Barriers to financing renewable energy sources include insufficient economic mechanisms related to the amount of cash outlays on energy installations, and high investment costs with low outlays related to the operation of unconventional energy systems. Long payback period for the project compared to the competitiveness of fossil fuel prices. The production of renewable energy systems is usually carried out by companies with a low level of capitalization for which survival in the face of long-term freezing of financial resources is a problem [47]. The document of the Supreme Audit Office shows that the main obstacles for the development of unconventional energy in the country are limited sources of investment financing by enterprises, legal support regulations and problems with the operation of transmission networks. Legislative work is currently underway on draft legal acts, including an amendment to the Act on Renewable Energy Sources, which are intended to help remove administrative barriers and accelerate the development of the renewable energy market [55].

The negligible nature of environmental barriers related to the use of renewable energy sources results from the small impact on the environment related to the emission of pollutants during the energy production process. Compared to fossil fuel energy, unconventional energy has a positive environmental effect [56]. However, many legal acts on nature and environmental protection regulate the location of installations. These regulations define zones in which it is not possible to locate energy infrastructure at all and its required distances from these zones. Another limitation barriers related to education and access to information constitute barriers for the Polish non-conventional energy sector. Information gaps regarding the functioning of production, design and consulting companies dealing with unconventional energy and the distribution of the energy potential of individual renewable energy categories. The lack of promotion and education about green energy is related to the unfavorable attitude of local communities regarding the location of renewable energy installations and the difficulty in generating demand for a specific technology. Societal education is one of the key factors enabling an increase in the share of non-emission energy in Poland's energy structure. The lack of an adequate database of institutions, scientific and research facilities, and companies from the renewable energy sector is a hindrance for investors. Despite extensive programs to educate and raise awareness in the population in the field of environmental protection, there is a lack of education about the energy sector and threats to conventional energy and its alternatives [57]. The information and education barrier affects the entire society. Lack of citizen awareness is often the cause of protests by local residents and difficulties in implementing the installation. Information problems contribute to the creation of myths in the field of renewable energy. One of them is the unreliability of installations and technologies. Atmospheric conditions influence the course of electricity production, but with the appropriate selection of installations, storage sources and skillful demand control, it is possible to maintain uninterrupted supplies of electricity [58].

Barriers to winter tourism and related infrastructure have their source in the economy, weather conditions, the specificity of this project and many other levels. The pace of development of the skiing base would be much faster if it were not for legal, ownership, functional and natural barriers. Legal barriers are related to the protection aspect of nature. Environmental protection regulations lengthen procedures and constitute an aspect that reduces the profitability of the project for investors [59]. Natura 2000 areas are a form of nature protection operating in Poland since 2004. In 2022, there were 999 Natura 2000 areas, of which 864 were forms of habitat protection covering a significant part of mountainous areas [60].

The winter sports sector is highly dependent on weather conditions. As temperatures have increased, the length of the ski season and the natural amount of snow cover are shortened. This factor leads to an increase in the costs of snowmaking, caused by an increase in the amount of snow necessary to produce and an increase in electricity prices worldwide. The instability of weather conditions also leads to difficulties in snow production; despite technological development, the snow-making process still requires a temperature below 0 °C and large water resources. Air temperatures that are too high prevent snow production and cause the melting of the natural snow cover, which translates into the poor functioning of ski slopes [61]. Intensive snowmaking of slopes also significantly affects the profitability of individual slopes. One of the considered barriers to the development of winter sports services is also the issue of safety for slope skiing and liability for accidents. Collisions on ski slopes are not a rare phenomenon, but they are usually caused by skiers themselves or people engaging in other types of activities. Many of them have accidents while descending and hold the owners of the winter infrastructure legally liable. Most incidents result from failure to comply with the rules of shared use by reckless driving, listening to music, moving along the entire width of the slope, lack of awareness of the surrounding situation and being under the influence of alcohol or drugs.

Analyzing the literature on the subject, the authors come to the conclusion that the technology for implementing Renewable Energy Sources in Polish mountain tourism conditions has not yet been fully developed and implemented at a utility scale. Reports appearing in the form of post-conference studies contain a lot of important information about the potential possibilities of using this technology as part of the sustainable development economy. The information available in the literature does not show detailed analyses, calculations and specific recommendations for such investments. The problem of the ecological development of mountain tourism areas prompts the authors to develop effective, economical and pro-ecological methods of their use, respecting the natural environment and the requirements of national and EU law as part of Poland's energy transformation.

3. Materials and Methods

The aim of the work is to assess the current state of ski infrastructure in terms of the possibility of using green energy to power these types of devices, with an indication of the profitability of this project.

In order to assess the profitability of transforming the energy structure in ski resorts, first of all, the costs associated with supplying the entity with conventional energy should be analyzed in detail. The research was carried out on the basis of the analysis of reports, own research and field research at Szczyrk Ski Resort S.A. in Szczyrk, Poland in the period 2019–2022. The research performed allowed for a detailed identification of the costs and benefits resulting from the proposed introduction of renewable energy installations, while also indicating the profitability of this project. The study used the SWOT (Strengths, Weaknesses, Opportunities, Threats), NPV (net present value) and IRR (internal rate of return) methodology. These analytical methods allowed for a comprehensive assessment of the economics focused on identifying the financial efficiency and profitability of introducing renewable energy installations in ski resorts.

When analyzing the installation of solar panels, it is worth remembering that it is a year-round installation. Moreover, excess energy generated in summer can be collected from the power grid within 365 days in a ratio of 1:0.8 or 1:0.7. Thanks to this, in winter we can use the electricity that the installation produced in summer. Therefore, the efficiency of photovoltaic panels in winter is not very important, what is important is the annual balance of energy produced. In the analyzed geographical destination—Poland, each installation, regardless of location, is able to produce more energy than the initial forecasts. Usually, the investor benefits because in the summer he is not able to fully use the electricity provided by the PV installation.

A separate issue seems to be the concern about significant changes in the landscape and the impact on the region's ecosystem due to the area covered by the photovoltaic installation. In this corresponding project, it was assumed that photovoltaic panels were placed on tourist infrastructure facilities associated with the ski lift, which directly reduces the impact on the natural environment.

3.1. Cost Analysis of Traditional Energy Sources

The subject and at the same time the main area of scientific research were the socio-economic and legal-economic conditions and environment related to renewable energy in Poland, which were studied in a measurable and non-measurable way. The analysis of the problem also took into account international legal conditions related to the implementation of the EU climate and energy policy. The research included entities participating in the energy value chain process, wholesale recipients and consumers of electricity, companies participating in the emission allowance trading system, as well as public administration bodies in Poland and the EU. The conducted research focused on entities operating in Poland. The time scope of the research included selected secondary data, with particular emphasis on the period 2019–2022. It should be noted that the data were collected and analyzed from actual implementation of production processes, which allowed us to propose remedial actions and correct production and service processes within the assumptions of the "just time" management philosophy. Two types of information sources were used in the research: sources of primary information, which came from field research in the ski resort, and sources of secondary information, which included, among others, bibliographic items, including domestic and foreign literature on the subject, in particular, documents of a legislative nature; Polish and EU legal acts, statistical materials, industrial research, industry reports and studies, surveys and numerous internet sources. The following methods were used in the individual stages of research:

- critical analysis of Polish and foreign literature on management and quality sciences and other materials constituting sources of secondary information,
- direct and indirect observation and free and focused interviews,
- collecting data from primary sources as part of control and secondary visits,
- analysis of statistical data from primary sources (derived from collected empirical data) and secondary sources,
- logical analysis when creating models and analyses of the results obtained during research,
- synthesis enabling combining the components isolated by analysis into a whole,
- mathematical and statistical analysis, enabling qualitative and quantitative presentation of the results of primary and secondary research,
- scientific reasoning combined with the processes of induction, deduction and modeling, used in the interpretation and synthesis of research results and in the creation of models.

3.2. Costs and Benefits of Introducing Green Energy

As part of this part of the research, the authors performed a SWOT analysis of the Polish coal sector and the renewable energy sector. As the literature on the subject indicates [62], SWOT analysis is one of the methods of strategic analysis that allows you to assess the organization's environment, both internal and external. A full SWOT analysis takes into account the relationship between strengths/weaknesses and opportunities/threats, as well as the importance of individual elements. Only after a full analysis will it be possible to select the appropriate strategy for the company. SWOT analysis is very helpful in risk planning. The ability to assess risk well is crucial for a business project. Opportunities and threats may affect an enterprise to varying degrees. Therefore, when developing a SWOT analysis, you need to determine not only what opportunities may arise but also how to use them to achieve market success. Moreover, the analysis should not only predict threats but also develop ways to deal with them. Internal analysis of the company involves describing its strengths and weaknesses, which are then compared with the strengths and weaknesses of the competition. When listing the company's strengths and weaknesses, you should not include all of its resources, but only those that may contribute to or limit success on the market. Too long a list of strengths and weaknesses indicates that the company has problems determining what is really important for its effective operation. Analysis of the company's environment (external analysis) comes down to describing the current state and predicting possible development options.

SWOT analysis, as a tool, is a comprehensive analysis that allows for freedom in the selection of techniques and procedures. Searching for the best development strategies takes a lot of time, and the lack of experience and appropriate knowledge in this field contributes to incorrect conclusions. The method described above, according to the authors in the case of the inability to present both numerical and cost data, is the most accurate approach when trying to assess the profitability of using renewable energy resources in ski resorts.

3.3. Project Profitability Index

The following economic indicators were used to assess the profitability of the investment: repayment period, net present value of future cash flows (NPV), and internal rate of return (IRR). The payback period is the time after which the initial expenditure for the implementation of the intended project is recovered. The formula was used to calculate the period with monthly accuracy [63]:

$$\boldsymbol{OZ = O_{PZ} + \frac{R}{CF_{OZ}}} \tag{1}$$

$\boldsymbol{O_{PZ}}$—number of the period at the end of which the cumulative flow is negative, preceding the return,

$\boldsymbol{R}$—the rest of the returned contribution at the beginning of the refund period,

$\boldsymbol{CF_{OZ}}$—cash flow over the payback period.

NPV, net present value, is a method of calculating the return on investment for a given project. It illustrates the present value of cash flow compared to the initial amount, at the required ROI. The method takes into account the time value of money and provides a specific number to compare the initial cash outlay with the present value of the return. The method adopts decision-making methods in the form of:

- NPV < 0—a given project should be rejected, generating losses,
- NPV = 0—meeting the minimum efficiency requirement, the investment will not generate either losses or income,
- NPV > 0—you can implement your plan and generate profits.

The net present value was calculated using the formula [64]:

$$NPV = \sum_{i=0}^{n} \frac{CF_i}{(1+k)^n} \tag{2}$$

CF_i—net cash flow for the year i (i = 0, 1, . . ., n),

k—required rate of return,

n—lifetime of the project effect in years.

The internal interest rate IRR is used to determine the actual rate of return of a specific project and is a measure of the profitability of an investment. The method is based on the interest rate at which discounted expenses equal the discounted values of capital inflows. IRR is the level of the discount rate for which the NPV is zero. Criterion rating:

- IRR > cost of obtaining capital—project profitability,
- IRR < cost of obtaining capital—lack of profitability.

4. Results and Discussion

4.1. Cost Analysis of Traditional Energy Sources

In order to thoroughly analyze the costs faced by ski resorts, a detailed analysis of the demand, processes and structure of Szczyrk Ski Resort was carried out. It is one of the most modern ski resorts in Poland, located in Szczyrk, in the Silesian Beskids. The infrastructure of the resort, in addition to extensive slopes with a length of almost 25 km, includes six lifts, one of which is a modern gondola capable of transporting 10 people, and three are couches with a capacity of loading six people each. Additionally, the resort has an extensive snow-making system, which increases the stability of the skiing conditions. It also offers an extensive catering sector, hotel and parking spaces to meet the needs of the guests. The costs of the center do not include water consumption. The company has a dam on the Potok Malinów river, located within the center, and a deep well to supply liquid to the infrastructure. Water is also pumped into the reservoir collecting liquid for snowmaking on the slopes. The amount of water used depends on the intensity of the ski tourism traffic, weather conditions determining the condition of the natural snow cover and the intensity of the artificial snow-making process. The analyzed period coincides with the COVID-19 pandemic, which caused difficulties in population migration and interruptions in the functioning of tourism in 2020. This situation represented a reduction in water consumption in 2020–2021, characterized by an almost 50% decrease in fluid consumption compared to 2019. In the case of a proper winter season, water consumption ranges from 80 to 100 thousand m^3 (Figure 1). The liquid is fully used for plant purposes, unrelated to production and not subject to international trade. A deep well is responsible for 1000 m^3 of fluid per year. Water used to maintain appropriate conditions on ski slopes is not discharged into the sewage system but absorbed by the ground on which there is a layer of artificial snow along with chemical substances. The annual amount of discharged sewage oscillates between 1000 and 4000 m^3 and is not subject to sewage treatment processes in the area of the analyzed entity.

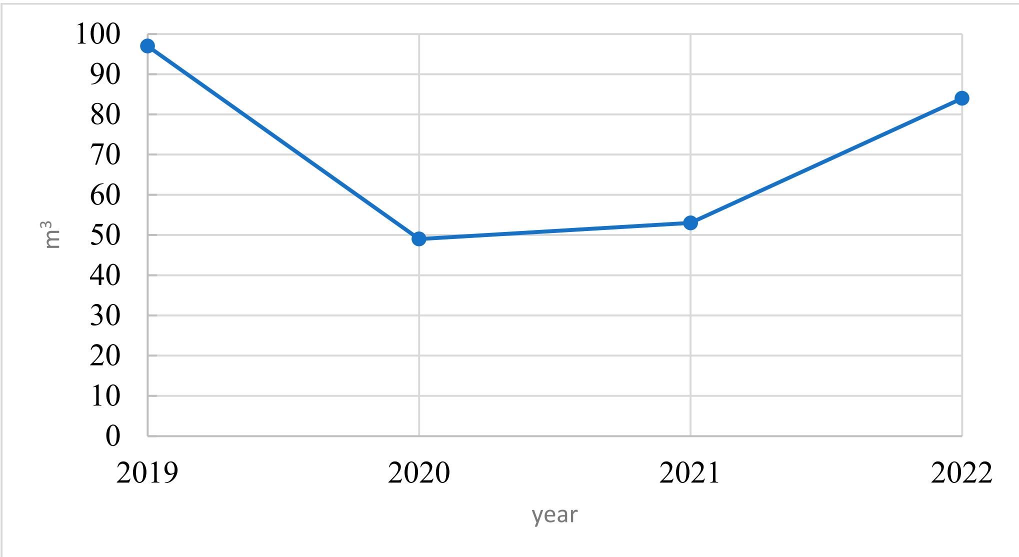

Figure 1. Water collected from the plant's intakes in the period 2019–2022 in thousands m^3 without decimal sign. Source: own study.

The ski resort uses energy carriers in the form of natural gas in a liquid or gaseous state, electricity, unleaded gasoline and diesel oil for diesel engines used to power a fleet of passenger vehicles and snow groomers. Natural gas is used in fuel combustion installations, in the form of factory boilers, responsible for the production and supply of heat in the form of steam and hot water for air conditioning systems. This heat is fully generated and used by the center. This process is accompanied by the release of greenhouse gases, which are characterized in the next section. The largest share of purchased energy carriers is electricity (Tables 1 and 2). However, there was a decline in this carrier compared to 2020. The share of natural gas increased by 3.13% over two years. The purchase of unleaded petrol increased by a tonne, which is an increase of 18.52% despite the unchanged vehicle fleet powered by this fuel. Diesel oils for diesel engines have recorded a 58.82% increase over the past two years despite the reduction in the fleet of vehicles using this type of fuel. The largest share of this process is caused by the use of groomers and slow-moving vehicles. The purchase of electricity decreased by 45.17%, despite this trend, the price paid by the center for the purchase of electricity increased by 35.07% over the years. In 2022, this cost amounted to EUR 14,344,200, EUR 3,724,650 more than in 2020. Expenditure on natural gas increased by EUR 119,700, which is 162.20% of the amount allocated to this medium two years earlier. Total expenditure on energy carriers in 2020 amounted to EUR 127,642.5. In 2021, these costs decreased by EUR 1,240,200, which constituted 90.28% of the amount in the previous year. Compared to the amount from two years ago, in 2022, the full cost of purchasing energy carriers increased by 50.41%. The change in the purchase value of individual energy carriers is shown schematically in Figures 2 and 3.

Table 1. Change in the volume of purchases of individual energy carriers in the reporting period 2020–2022.

Name of the Energy Carrier	Total Purchase		
	2020	**2021**	**2022**
Natural gas in liquid or gaseous state, nitrogen-rich, [dm^3]	86.3	85.1	89
Motor gasoline, unleaded, [t]	5.4	5.7	6.4
Diesel oils for diesel engines, [t]	46.7	47.2	73.7
Electricity, [MWh]	7959.9	6540.6	4364.8

Source: own study.

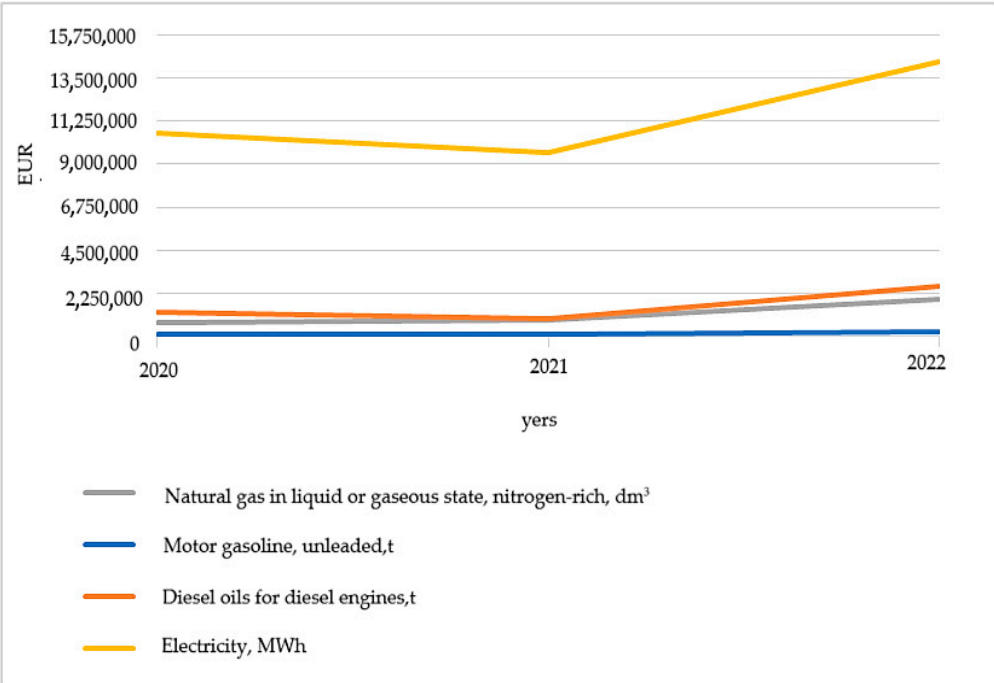

Figure 2. Change in the purchase value of individual energy carriers in EUR (excluding VAT) in the reporting period 2020–2022. Source: own study.

Table 2. Change in the value of purchases of individual energy carriers in EUR (excluding VAT) in the reporting period 2020–2022.

Name of the Energy Carrier	Value in EUR (Excluding VAT) 2020	2021	2022
Natural gas in liquid or gaseous state, nitrogen-rich, [dm^3]	738,000	851,400	1935
Motor gasoline, unleaded, [t]	145,800	116,550	275,400
Diesel oils for diesel engines, [t]	1,260,900	931.5	2,643,750
Electricity, [MWh]	10,619,550	9,624,600	14,344,200
Sum	12,764,250	11,524,050	19,198,350

Source: own study.

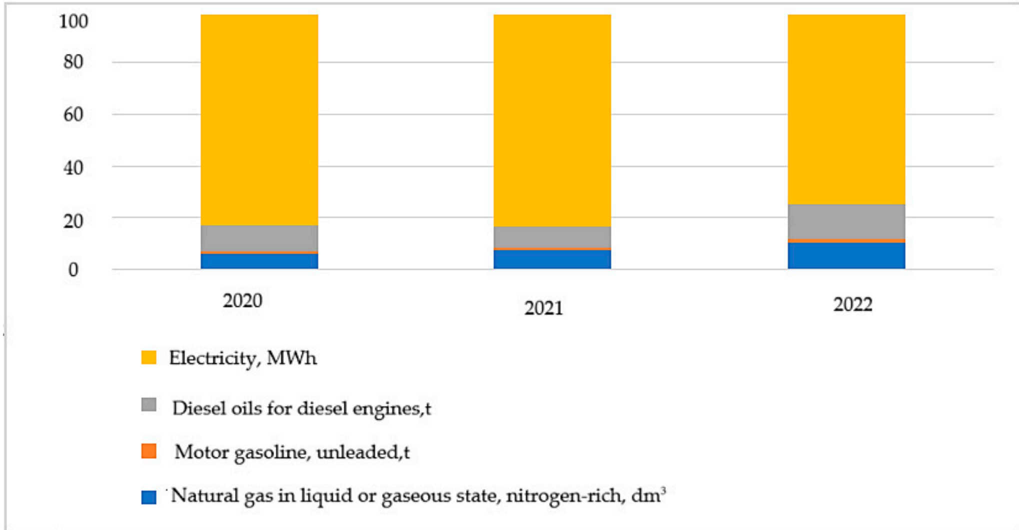

Figure 3. Change in the value of the percentage of purchase prices of individual energy carriers in EUR (excluding VAT) in the reporting period 2020–2022. Source: own study.

Research for the years 2019–2022 was carried out based on measurements and reports on water management and energy carrier balancing. Sample measurement results for the selected reporting period of 2022 are presented in Tables 3 and 4.

Table 3. Report on water management for the 2022 reporting period.

Specification		dm^3 (Thousand m^3/Year)
Water taken from the plant's intakes	underground (from a well)	1
	surface inland	83
	internal marine waters	0
	from drainage of mining plants and construction facilities	0
	Total	84
Purchasing water from other entities		0
Water consumption for the plant	Total	84
	including for production	0
Water sales		0
Water losses in the network		0

Source: own study.

Table 4. Balance report of energy carriers for the reporting period 2022.

Name of the Energy Carrier	Unit of Measure	Production	Total Purchase		Other Income	Sale		Other Income	Wear
		Quantity		Value in EUR (Excluding VAT)	Quantity	Value in EUR (Excluding VAT)		Quantity	
Natural gas in liquid or gaseous state, nitrogen-rich	dm^3	0	382,950	851.4	0	0	0	0	382.95
Motor gasoline, unleaded	t	0	25,650	116.5	0	0	0	0	2565
Diesel oils for engines (diesel)	t	0	212,400	931.5	0	0	0	0	21,240
Electricity	MWh	0	29,432,700	9624.6	0	0	0	0	29,432.70
Heat in steam and hot water	GJ	7348.5	0	0	0	0	0	0	7348.5

Source: own study.

4.2. Costs and Benefits of Introducing Green Energy

In order to thoroughly examine the benefits of introducing RES installations into the energy structure of the company, a SWOT analysis was carried out (Table 5), comparing unconventional energy with the current use of hard coal, which is the main energy raw material in Poland. The SWOT analysis method is a proven tool in diagnostics and strategic management, used in many economic sectors. It allows you to determine the Strengths and Weaknesses of a given issue, i.e., internal factors constituting the advantages or disadvantages of the analyzed area, respectively. Additionally, it identifies Opportunities and Threats related to a given project, resulting from external factors that may lead to changes, providing impulses for development or constituting potential difficulties and barriers. Moreover, the presented comparative SWOT analysis may be helpful in the process of strategic planning of the energy transformation of ski resorts in Poland. By creating a basis for discussion on remodeling the method of obtaining electricity, while enabling the assessment of the economic and energy efficiency of the project and its compliance with the assumed goals.

The strengths of the continued use of coal as an energy raw material in Poland's energy sector include its widespread resources available in the country. It is the cheapest of the conventional energy raw materials. It ensures the state's energy security, as in 2021, energy consumption from coal accounted for over 42% of total energy consumption in Poland. The technologies used in coal-burning power plants were comprehensively tested and developed. Developed technologies and qualified miners are used to extract the raw material. The weaknesses of this energy sector are largely related to the negative environmental impact and emissions of chemical compounds into the atmosphere. The remaining coal deposits in the country are characterized by largely unfavorable locations and depths; in some cases, extraction costs exceed the profitability of the project or are unfeasible due to insufficient scope, innovation and the poor financial situation of the mine. The development opportunities of the coal sector are influenced by the high demand for the raw material and its contribution to the country's energy security. This sector is responsible for many jobs. Modernization of extraction methods and exploitation of new deposits will increase the availability of the raw material. A significant opportunity in the conventional energy sector is research into clean technologies for the processing of non-renewable energy sources, characterized by reduced emissions of harmful gases, dust and heavy metals. An important aspect that poses a threat to the use of coal is the EU's climate policy, which aims to achieve emission neutrality by member states by 2050. The threat is posed by common knowledge about the impact of conventional energy on the environment and the competitiveness of energy carriers, especially in the green energy sector. Coal imports and their surplus on the market also constitute a barrier. The presented analysis paid more attention to the weaknesses of the energy sector. Long-term forecasts for coal use show a downward trend. A significant share of Poland's energy balance will be replaced by new technologies and the development of renewable energy sources by 2050. Despite its advantages, coal mining in Poland conflicts with the EU strategy. The SWOT analysis of the renewable energy sector is presented in Table 6.

Table 5. SWOT analysis of the Polish coal sector.

Strengths
– common raw material resources, – possibility of increasing coal extraction per year, – the cheapest of the conventional energy raw materials, – ensures the country's energy security, – dominance of the raw material in the energy balance, – extensive distribution network, – developed research sector, – developed mining technologies, – qualified miners.
Weaknesses
– negative environmental impact, – high level of greenhouse gas emissions, – increase in sales of coal substitutes, – change in buyer needs, – unprofitable extraction of some raw material deposits, – large depths and operating costs.
Chances
– high demand for raw materials, – participation in the state's energy security, – creation of new jobs, – research on clean coal processing technologies, – significant customer base, – mining of new deposits, – high demand for electricity.
Threats
– EU climate policy, – national energy and climate plan, – common knowledge about the impact of conventional energy on the environment, – import of coal from abroad, – surplus of raw material on the market, – possible reduction in the efficiency of mechanisms and technologies, – required infrastructure modernization, – high dependence on the economic situation.

Source: own study.

The advantages of the Polish energy sector based on renewable energy sources include all positive environmental aspects, which include reducing the use of non-renewable sources, reducing greenhouse gas emissions and harmful substances such as benzo(a)pyrene and PM10 and PM2.5 dust. In many cases, renewable energy sources depend solely on weather conditions, which makes them somewhat inexhaustible. Increasing the installed capacity of unconventional technology is a gradual process that does not require the simultaneous transformation of large areas into power plants. These activities lead to the quick implementation of investments. Energy bringing countries closer to achieving climate neutrality is an activity promoted in the EU. The disadvantages of this type of energy include the still inadequately adapted and underdeveloped energy network. Climatic conditions in Poland in the form of average annual sunshine in the region, wind speeds and terrain are unfavorable elements that prevent the full-scale development of renewable energy sources. Many unconventional energy technologies, despite low operating costs, are characterized by high investment costs in the implementation and initial operation process. Another negative aspect results from insufficient awareness of the local community and long-term administrative procedures related to the implementation of the investment. Significant opportunities to further increase the share of this type of energy in the energy structure are the EU energy policy and long-term plans adopted by member states. They create opportunities for economic development, new jobs and an area for the inflow of technology and investments. External development impulses also include reducing emissions of greenhouse gases and harmful substances into the atmosphere and the natural environment. Growing public awareness of sustainable development and nature protection forces, to some extent, cooperation between investors and ecological companies. Negative external factors related to the threat of insufficient public awareness are conflicts in the implementation of some forms of renewable energy. Threats may also include the variability of legal acts or the introduction of regulations due to insufficient information on the impact of a given form of unconventional energy on the region. Additionally, if violations of the use of funds granted by the EU are found, the commission may take disciplinary action against the entity.

Table 6. SWOT analysis of the renewable energy sector.

Strengths
– reducing the extraction of non-renewable energy raw materials, – energy production dependent solely on weather conditions, – quick implementation of investments, – component of the process of achieving climate neutrality, national energy and climate action plan, – low operating costs, – increased social acceptance, – national instruments supporting transformation.
Weaknesses
– insufficiently adapted and developed energy network, – investor uncertainty caused by lack of regulatory stability, – high cost of stabilizing the power system, – climatic conditions in the country, – high investment costs in the implementation process and the initial phase of operation, – insufficient awareness of the local community, – long administrative procedures, – lack of common knowledge and education in the field of modern solutions, – dominance of coal in the country's energy balance.
Chances
– EU energy policy and long-term plans adopted by member countries, – area of inflow of new technologies and investments, – growing public, social and administrative awareness of sustainable development and nature protection, – rising energy prices, – creation of new jobs, – consumer interest in ecology.
Threats
– conflicts in the implementation of some forms of renewable energy, – variability of legal acts, introduction of regulations hindering the implementation of projects, – potential discrepancy between declarative and actual involvement in pro-ecological activities, – the problem of attracting investors, – EU capital conditionality.

Source: own study.

Air pollution resulting from emissions of sulfur oxides, nitrogen, carbon and suspended dust may contribute to the deterioration of health. They lead to the development of asthma, allergies, reduced lung parameters and may shorten human life. Long-term exposure to harmful substances, even though they do not exceed the accepted parameters, is also harmful. The presence of sulfur oxides in the atmosphere negatively affects sensitive ecosystems and may significantly affect human health through its irritating effect on the respiratory tract. Sulfur compounds contribute to ailments such as conjunctivitis, lower overall immunity, and respiratory infections. Nitrogen oxides are a group of compounds that are a product of combustion and are difficult to eliminate from this process. Exposure to excessive concentrations of nitrogen dioxide may initiate an inflammatory process and damage the lungs. CO_2 is a greenhouse gas whose emissions have a significant impact on increasing the temperature of the Earth's surface. Suspended dust and Benzo(a)pyrene are components of smog. PM10 dust is a mixture of liquid and solid particles with a diameter of no more than 10 µm, while PM2.5 dust particles do not exceed 2.5 µm. Due to their size, dust can penetrate the lower respiratory tract, and in the case of PM2.5, even into the bloodstream. PM10 has a negative impact on the respiratory system, causes coughing attacks, bronchitis and worsens the condition of people with asthma, and indirectly increases the risk of heart attack and stroke. Due to its size, PM2.5 occurs in the form of an aerosol. This dust is the most dangerous for human health and is responsible for ailments such as weakening lung parameters, heart rhythm disturbances, atherosclerosis, and respiratory cancer. Benzopyrene, found in PM10 dust, is a chemical compound that is extremely harmful to the human body due to its carcinogenic nature, has a cumulative ability in the body, may impair fertility, damage the kidneys and weaken the immune system.

In 2022, in the analyzed entity (Table 7), the emission of Benzo(a)pyrene increased by 185.24 µg compared to 2020, this amount represents an emission increase of 7.60%. The only substances that recorded a decrease in the analyzed period are nitrogen and sulfur oxides by 12.11% and 30.50%, respectively. Compared to 2021, nitrogen oxides recorded an even greater decrease in occurrence. Suspended dust was characterized by the highest increase in emissions over the two years, an increase of 22.16% compared to the value in 2020. The amount of PM2.5 and PM10 dust emissions differs from the amount of total dust in the first year of analysis due to the lack of distinction in the case of one of the gas boilers. CO_2 constitutes on average over 99.87% of the share in the emission of the analyzed substances in the entity Szczyrk Ski Resort. S.A. in the reporting period 2020–2022 (Figure 4). The remaining emission volume is accounted for on average by nitrogen oxides, 60.51% and carbon monoxide, 38.24%.

Table 7. Emission rates of specific types of pollutants resulting from the combustion of fuel in the form of liquid or gaseous natural gas, high-methane in gas boilers in 2020–2022 at Szczyrk Ski Resort.

Name of the Substance	Emission Volume [kg]		
	2020	2021	2022
Carbon dioxide (Carbon dioxide CO_2)	174,629.430	179,328.984	189,067.477
Total dust	1.342	1.555	1.640
Dust PM10	1.337	1.555	1.640
Dust PM2.5	1.337	1.555	1.640
Benzo(a)piren	2.438×10^{-6}	2.489×10^{-6}	2.624×10^{-6}
Carbon monoxide (CO)	83.302	93.320	98.387
Nitrogen oxides (NOx/NO_2)	149.263	155.533	131.183
Sulfur oxides (SOx/SO_2)	1.888	1.244	1.312

Source: own study.

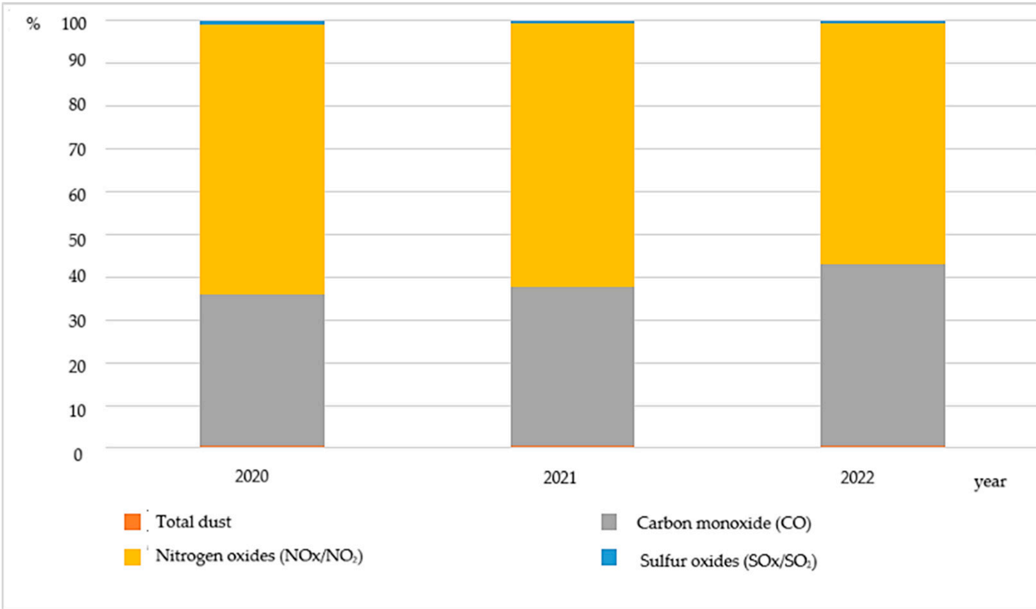

Figure 4. Share of selected substances in the annual emission structure of Szczyrk Ski Resort in the reporting period 2020–2022. Source: own study.

In the reporting period 2020–2022, electricity consumption in Szczyrk Ski Resort ranged between 4364.8 and 7959.9 MWh (Table 1). This demand depended on weather conditions, the length of the winter season, the size of the natural snow cover and demand. In order to replace this amount with energy from renewable energy sources, the most advantageous solution, based on the illustrated examples of the use of unconventional energy on ski slopes in various parts of the world, is to install a wind turbine or solar panels. Depending on the company that assembles and distributes the installation, there is a wide range of kWp for each 1000 kWh. The common ratio of 1.25 kWp for every 1000 kWh was adopted for the analysis. The cost of the installation depends on its size; solar panels with higher power are more profitable. For small installations in the range of 3–10 kW, the price per unit is EUR 13,500–40,500. For the need to calculate the costs of replacing electricity from conventional sources with renewable energy in the Szczyrk Ski Resort, the annual energy demand was assumed at the level of 6300 MWh, which is the rounding of the average purchase of electricity in the years 2020–2022. The adopted size corresponds to an installation with a power of 7875 kWp. Purchase and installation costs range between EUR 135,000,000 and 157,500,000, depending on the slope of the terrain and the method of use.

To achieve these values using wind energy, assuming the efficiency of windmills in Poland at the level of 4000 h per year, an installation with a capacity of 1575 kW is needed. The cost of building an onshore wind farm in Poland in 2022 was EUR 1.2 million/MW.

4.3. Project Profitability Index

The profitability parameters of the solar energy project in Szczyrk Ski Resort, selected on the basis of research and analyses, as representative and subject to economic assessments, have the following technical and economic characteristics, which are presented in Tables 8 and 9. The efficiency of photovoltaic panels largely depends on their efficiency. The efficiency of a PV panel determines how much solar energy a photovoltaic cell can convert into electricity. Efficiency is defined as a percentage. It is also calculated in the so-called standardized test conditions, i.e., with solar radiation exposure of PV panels at the level of 1000 W/m^2 at a temperature of 25 °C. In this case, monocrystalline panels from one of the leading manufacturers were selected for analysis.

Table 8. Assumptions for the profitability analysis of the project of using solar energy in the Szczyrk Ski Resort.

Parameters	Value
Installation power, [kWp]	7875
Annual demand for electricity, [kWh]	6,300,000
Nominal annual energy yield of the system, [kWh/kWp]	1039.8
Annual drop in system performance, [%]	0.7
Investment cost, [EUR]	153,000,000
Annual operating costs, [EUR]	22,500,000
Annual drop in system performance	25
Estimated cost of replacing the inverter in the 15th year of operation, [EUR]	180,000,000
Level of self-consumption of generated energy, [%]	40.0
Energy purchase tariff, [EUR/kWh]	5.40
Unit price of energy consumed from the network, [EUR/kWh]	3.28
The inflation rate of prices of goods and services on the market, [%]	8.2
Inflation rate of electricity purchase prices, [%]	24.0
Rate of return on safe capital investment, [%]	6.6
Inflation rate of electricity sales prices, [%]	20.0

Source: own study.

Negative cash flows occur at the beginning of the investment, capital expenditure equal to EUR 153,000,000, up to the 4th year of the analysis and in the 15th period, at the expected moment of replacing the inverter. The cash flow of the investment is shown in Figure 5.

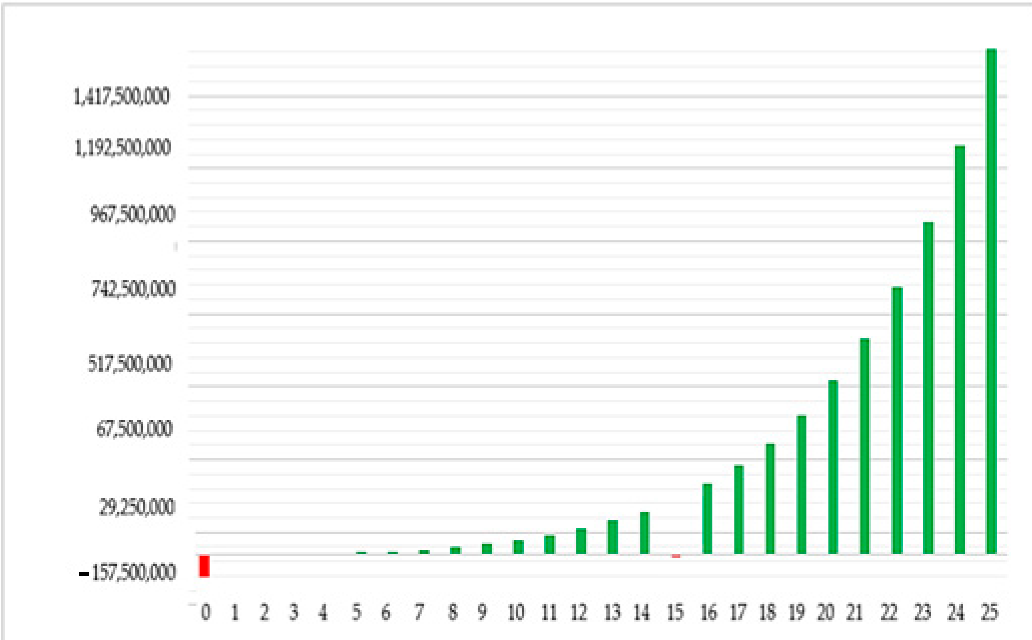

Figure 5. Investment cash flow [EUR]. Source: own study.

Based on the accumulated cash flows (Figure 6) and formula (1), the payback period for the invested capital was determined; the period after which the net proceeds from the project will be equal to the incurred expenses is 10 years and 10 months.

The value of the calculated NPV (Table 10) is greater than zero, the IRR exceeds the market rate of safe capitalization investment at the level of 6.6%, which is the opportunity cost of investing capital. These results indicate the profitability of the analyzed project over the traditional form of purchasing electricity. The summary of expenditure on electricity from traditional sources and the installation of panels is presented schematically in Figure 7.

Table 9. Analysis of the profitability of investing in photovoltaic panels for the Szczyrk Ski Resort.

Year	Efficiency *, [%]	Installation Power, [kWp]	Energy Yield, [kWh/Year]	Auto Energy Consumption, [kWh]	Energy Sales Price, [EUR/kWh]	Revenue from Energy Sales Less VAT, [EUR]
1	100	7875.00	8,188,425.00	3,275,370.00	1.800	6,809,494.230
2	99.30	7819.88	8,131,106.03	3,252,442.41	2.160	8,114,193.324
3	98.60	7764.75	8,073,787.05	3,229,514.82	2.610	9,668,392.286
4	97.90	7709.63	8,016,468.08	3,206,587.23	3.105	11,519,703.100
5	97.20	7654.50	7,959,149.10	3,183,659.64	3.735	13,724,802.550
6	96.50	7599.38	7,901,830.13	3,160,732.05	4.500	16,351,153.660
7	95.80	7544.25	7,844,511.15	3,137,804.46	5.355	19,479,053.110
8	95.10	7489.13	7,787,192.18	3,114,876.87	6.435	23,204,066.180
9	94.40	7434.00	7,729,873.20	3,091,949.28	7.740	27,639,922.370
10	93.70	7378.88	7,672,554.23	3,069,021.69	9.270	32,921,958.380
11	93.00	7323.75	7,615,235.25	3,046,094.10	11.160	39,211,211.900
12	92.30	7268.63	7.557.916,28	3,023,166.51	13.365	46,699,288.520
13	91.60	7213.50	7,500,597.30	3,000,238.92	16.065	55,614,147.260
14	90.90	7158.38	7,443,278.33	2,977,311.33	19.260	66,226,977.990
15	90.20	7103.25	7,385,959.35	2,954,383.74	23.130	78,860,375.100
16	89.50	7048.13	7,328,640.38	2,931,456.15	27.720	93,898,051.920
17	88.80	6993.00	7,271,321.40	2,908,528.56	33.300	111,796,384.500
18	88.10	6937.88	7,214,002.43	2,885,600.97	39.915	133,098,128.100
19	87.40	6882.75	7,156,683.45	2,862,673.38	47.925	158,448,713.600
20	86.70	6827.63	7,099,364.48	2,839,745.79	57.510	188,615,608.300
21	86.00	6772.50	7,042,045.50	2,816,818.20	69.030	224,511,312.300
22	85.30	6717.38	6,984,726.53	2,793,890.61	82.800	267,220,673.600
23	84.60	6662.25	6,927,407.55	2,770,963.02	99.360	318,033,326.900
24	83.90	6607.13	6,870,088.58	2,748,035.43	119.250	378,482,214.500
25	83.20	6552.00	6,812,769.60	2,725,107.84	143.100	450,389,324.300

Year	Energy Purchase Price, [EUR/kWh]	Energy Purchase Cost, [EUR]	Current Expenses, [EUR]	Energy Cost without Installation, [EUR]	Cash Flow, [EUR]	Cumulative Cash Flow, [EUR]
0			153,000,000.0		−153,000,000.000	−153,000,000.000
1	3.285	9,935,909.55	22,500,000.00	20,695,500.00	−4,930,915.320	−157,930,915.300
2	3.285	10,011,226.68	24,345,000.00	20,695,500.00	−5,546,533.365	−163,477,448.700
3	4.095	12,507,314.31	26,341,290.00	25,662,420.00	−3,517,792.065	−166,995,240.700
4	5.040	15,624,877.41	28,501,275.78	31,821,400.80	−785,049.255	−167,780,290.000
5	6.255	19,518,449.45	30,838,380.39	39,458,537.01	2,826,509.715	−164,953,780.300
6	7.785	24,380,943.08	33,367,127.58	48,928,585.86	7,531,668.855	−157,422,111.400
7	9.630	30,453,171.03	36,103,232.07	60,671,446.47	13,594,096.530	−143,828,014.900
8	11.925	38,035,726.07	39,063,697.07	75,232,593.63	21,337,236.680	−122,490,778.200
9	14.805	47,503,804.82	42,266,920.23	93,288,416.09	31,157,613.410	−91,333,164.830
10	18.360	59,325,703.61	45,732,807.68	115,677,636.00	43,541,083.040	−47,792,081.790
11	22.770	74,085,894.63	49,482,897.93	143,440,268.60	59,082,687.950	11,290,606.160
12	28.215	92,513,816.87	53,540,495.55	177,865,933.10	78,510,909.150	89,801,515.310
13	35.010	115,519,794.20	57,930,816.20	220,553,757.00	102,717,293.900	192,518,809.200
14	43.425	144,239,844.80	62,681,143.14	273,486,658.70	132,792,648.800	325,311,457.900
15	53.820	180,091,579.50	67,820,996.84	339,123,456.80	−9,928,744.515	315,382,713.400
16	66.735	224,843,931.90	73,382,318.60	420,513,086.40	216,184,887.800	531,567,601.200
17	82.755	280,704,138.40	79,399,668.74	521,436,227.10	273,128,804.500	804,696,405.700
18	102.645	350,426,233.60	85,910,441.58	646,580,921.60	343,342,374.500	1,148,038,780.000
19	127.260	437,446,376.10	92,955,097.76	801,760,342.90	429,807,582.600	1,577,846,363.000
20	157.815	546,051,635.90	100,577,415.80	994,182,825.10	536,169,381.800	2,114,015,745.000
21	195.660	681,590,509.20	108,824,763.90	1,232,786,703.00	666,882,742.400	2,780,898,487.000
22	242.640	850,735,467.40	117,748,394.50	1,528,655,512.00	827,392,323.600	3,608,290,811.000
23	300.870	1,061,810,392.0	127,403,762.90	1,895,532,835.00	1,024,352,007.000	4,632,642,817.000
24	373.095	1,325,198,918.0	137,850,871.40	2,350,460,715.00	1,265,893,140.000	5,898,535,958.000
25	462.645	1,653,853,658.0	149,154,642.90	2,914,571,287.00	1,561,952,310.000	7,460,488,268.000

Source: own study. * In terms of the efficiency of photovoltaic cells, it is also worth mentioning that their efficiency decreases during operation. This phenomenon results indirectly from the loss of power of PV panels resulting from their degradation. This is a natural process. Modernly manufactured and properly installed PV panels lose no less than 0.3–0.5% of their nominal power per year. The greatest decline in the efficiency of photovoltaic cells occurs in the first year of their operation and may reach up to 5%. After approximately 3 years, the rate of power loss decreases significantly. It is also worth mentioning that each PV panel manufacturer provides a minimum 25-year yield warranty, which protects the investor in the event of an excessive decline in the efficiency of the PV panel.

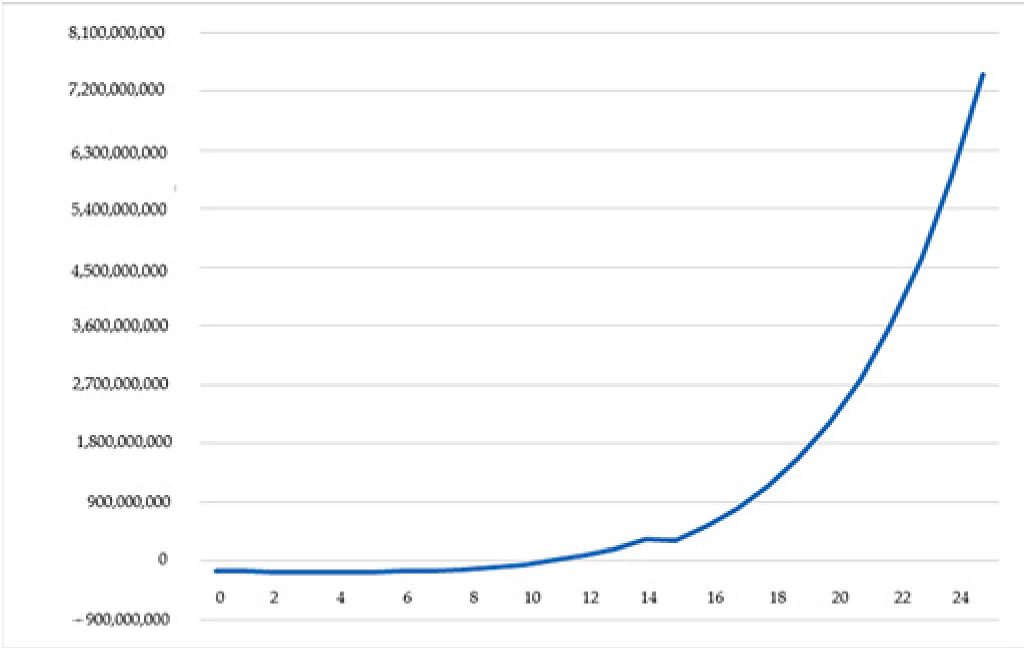

Figure 6. Cumulative investment cash flow [EUR]. Source: own study.

Table 10. NPV and IRR along with the evaluation criterion.

Name	Size	Criterion
Net present value, [EUR]	1,821,234,989.205	NPV > 0
Internal interest rate, %	17.57	IRR > Cost of raising capital

Source: own study.

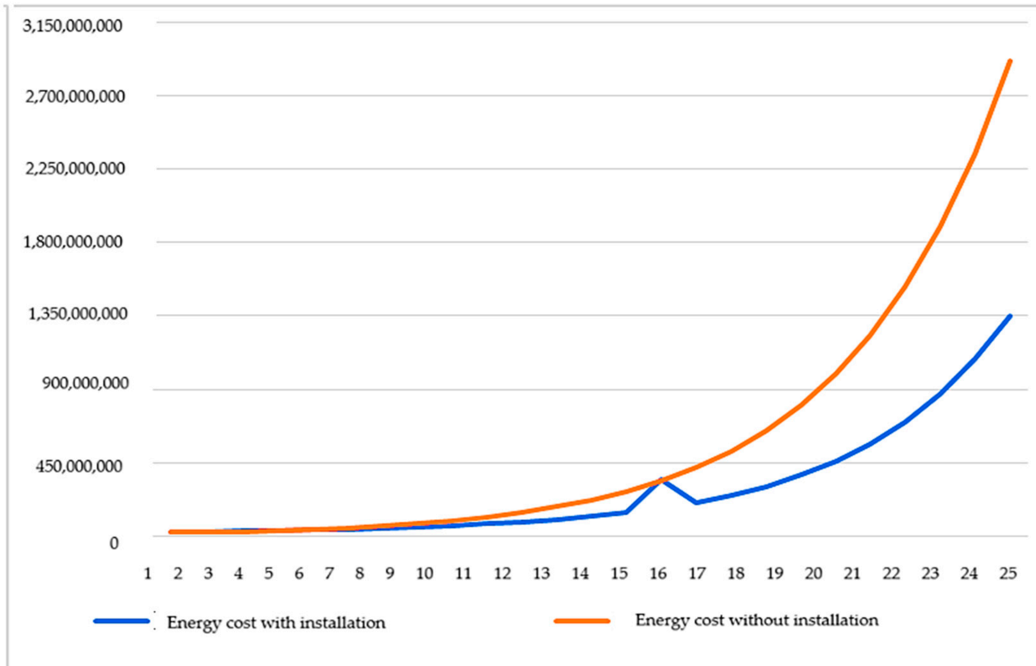

Figure 7. Summary of expenses for electricity from traditional sources and installation of photovoltaic panels [EUR]. Source: own study.

5. Conclusions and Discussion

The research topic concerned the assessment of the current state of ski infrastructure in terms of the possibility of using green energy to power these types of devices, with an indication of the profitability of this project. This is a particularly important topic in the context of the impact of tourism on the ecosystem and the energy transformation of all sectors of the country. The literature in Polish and English was analyzed in order to thoroughly examine the issues constituting the research elements of the work. The literature presenting the methods used, and the reports of entities from the energy sector and the ski resorts were analyzed. The theoretical part of the work presents technologies classified as green energy, their sources, their impact on the environment and their share in the energy structure of the country. A number of possibilities for using renewable energy technologies in the ski resort sector were identified by illustrating the use of unconventional energies on slopes around the world. One of the subchapters is devoted to the issue of energy transformation, and the share of the selected energy carriers in the energy balance of the EU, member states and Poland. The country's plan to reduce emissions by 2030 and achieve climate neutrality by 2050 was analyzed. The work identifies barriers to renewable energy sources and ski resorts as key elements of the project, and a number of reasons limiting development are indicated. A separate subchapter is dedicated to the impact of ski slopes and accompanying infrastructure on the environment. Threats to fauna and flora resulting from tourism, the creation and operation of winter sports facilities and local development due to the attractiveness of the region were indicated. User expectations and components of the sector's competitive environment were analyzed.

The following research hypothesis was put forward: renewable energy can be an effective source of power for ski resorts while limiting the negative impact on the natural environment. The carriers and costs of traditional energy sources used in ski resorts were analyzed based on reports from one of the largest entities in the country. A SWOT analysis was used both in the context of renewable energy and the Polish coal sector to indicate the benefits of energy transformation. A list of pollutant emissions by ski resorts and a cost estimate for changing energy carriers to renewable energy sources were prepared. The indication of the profitability of the project was based on the assumptions made regarding individual technical and financial parameters of the implementation of solar energy in the form of photovoltaic panels in the analyzed center. The investment payback period, NPV indicating the return on the project and IRR, which is a measure of the investment's profitability, were calculated, allowing for confirmation efficiency of renewable energy sources in the context of powering ski resorts. The work is a comprehensive approach to the analyzed issues and an element enabling entities to make decisions regarding the energy transformation in the ski sector.

Through a review of the theoretical materials included in the presented topic and an analysis of the profitability of the project, the following conclusions can be drawn:

1. Renewable energy sources are a basic element of the energy transformation in Poland and the EU; they are a key element in the transformation of the energy structure of countries and eliminate negative environmental effects, as is the case in the energy sector based on fossil fuels. Investment in unconventional energy can reduce the negative impact of various sectors, including ski resorts, on the environment.
2. By illustrating examples of the use of green energy on ski slopes in different parts of the world, solar and wind energy can be distinguished as independent energy sources suitable for implementation by ski resorts. Energy obtained from biomass power plants is also an environmentally neutral solution and constitutes an alternative source of power for the infrastructure.
3. The barriers hindering the development of both renewable energy sources and the ski resorts themselves are mainly related to legal and social obstacles. They result from the presence of nature protection areas, incorrect construction of legal acts, and bureaucracy problems related to the lack of knowledge about the specificity of renewable energy and EIA. The social factor is related to protests, which result largely from communication problems. Reducing the severity of these barriers or eliminating them completely is a key aspect of change in Poland's energy mix and the

development of the winter sports sector. Ski areas may be another way to increase the share of non-conventional energy in the tourism sector.

4. The cost structure of traditional energy sources used in the audited entity was analyzed. The possibility of investing in renewable energy technologies was indicated by presenting the share of electricity costs in the overall share of types of energy carriers used by ski slopes. It is at the level of 74.72–83.52%, depending on the year, which suggests the possibility of reducing costs and increasing efficiency through investments in unconventional energy.
5. The benefits of introducing green energy were indicated through a SWOT analysis of the Polish coal sector, which is the main energy carrier in the country, and renewable energy technologies. The significant share of mining raw materials in the energy structure of EU member states is inconsistent with the institutions achieving climate neutrality by 2050. Moreover, the exploitation of remaining deposits is in many cases unprofitable, the location of the deposits affects the costs of the project, which in many cases exceeds its profitability. Green energy is environmentally friendly, is accepted by the EU and is self-sufficient and depends only on the country's weather conditions. It limits the emission of compounds such as benzo(a)pyrene, carbon oxides, sulfur and nitrogen oxides and PM10 and PM2.5 dust.
6. The profitability of the project in the form of a photovoltaic installation with a capacity of 7875 kWp was indicated, taking into account the average lifespan of the system, inverter replacement, nominal annual energy yield, investment and operating costs along with their change in value over time. The payback period for the invested capital is 10 years and 10 months. The positive value of NPV and IRR proves the possibility of implementing the assumed plan and the profitability of the project related to its generation of profits. This analysis confirms the profitability of implementing unconventional energy from the winter sports industry.

It is important to emphasize that the presented research focused on assessing the possibility of implementing solutions based on energy from renewable energy sources in terms of their use for ski infrastructure. It is important to answer the question of whether the project itself and the research conclusions can be directly implemented or compared to other regions where the role of renewable energy sources is increasing. According to researchers, the implementation of this category of projects should be individual. Duplicating common assumptions and patterns is not advisable because different geographical destinations are based on different initial assumptions. This does not change the fact that in each case, starting from the planning stage through to construction and operation, a process approach may turn out to be key to achieving success, which will include a comprehensive analysis resulting from the replacement of conventional energy systems with new ones based on renewable energy. Therefore, it should be remembered that a possible comprehensive assessment of all the political and economic consequences of these changes will only be possible several years after the implementation and launch of individual projects.

In the discussion about photovoltaic installations, the issues of their production and disposal seem to be no less important. Previous generations of photovoltaic cells ensured a service life of at least 25 years [63]. Currently produced PV panels are made of newer materials and use more innovative technological processes, thanks to which they not only provide longer service life and better technical parameters but also their production process is less harmful to the natural environment. It is estimated that photovoltaic panels from a group of leading manufacturers currently introduced to the market are able to ensure a service life of up to 40 years. Therefore, by then, their disposal and recycling process will certainly be more refined, and the costs could be significantly optimized.

The authors support the thesis promoted in the literature on the subject that renewable energy is an opportunity for the development of sustainable tourism and the creation of a new style of operation in the tourism industry, including the ski resorts themselves [64,65]. Coherent, pro-environmental tourist activities will have a direct impact on the increase in the competitiveness of the region. Balancing energy efficiency and maintaining high-quality services seems to be an important requirement. For this purpose, it is necessary for the tourism industry to interact with other sectors of the local economy in order to create an autonomous energy region including the development of intelligent energy networks based on the diversification of energy from several renewable energy sources.

Future research should identify and develop new renewable energy generation, storage and efficiency projects that should benefit both the ski resorts and the entire valley. The technical and technological infrastructure should also be prepared for water abstraction, which should come 100% from recycled snow. As part of the energy transformation of ski slopes, self-sufficiency of ski resorts should be sought, and to this end, efforts should be made to:

- maximum energy efficiency: renovation of buildings and development of e-mobility, as well as greater emphasis on walking and cycling,
- decarbonization of buildings: replacing oil heating systems and using climate-friendly building materials,
- solar architecture: installation of photovoltaic panels on roofs and facades, as well as the creation of buildings with a positive energy balance,
- electrification of mobility: the use of battery vehicles and hydrogen and expansion of charging infrastructure,
- large-scale power plants: obtaining all energy demand from photovoltaic and hydroelectric power plants and wind farms,
- energy storage: use of storage lakes, hydrogen and batteries.

The authors believe that climate change is one of the most important challenges facing every country, every company and every person on this planet. We are all responsible for solving this problem at every stage of the development of production and services, including sports and recreation.

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Abbreviations

OZE	renewable energy sources
UE	European Union
MW	megawatt
GW	Gigawatt
kW	Kilowatt
TW	Terawatt
TWh	terawatt hour
OTEC	Ocean Thermal Energy Conversion
GWh	gigawatt hour
MWh	megawatt hour
CO_2	carbon dioxide
BP	British Petroleum Statistical Review of World Energy
EJ	Exajoule
Mtoe	mega tonne of oil equivalent

PKB	Gross Domestic Product
KPEiK	National Energy and Climate Plan
KE	European Commission
OOŚ	environmental impact assessment
NPV	Net Present Value
IRR	Internal Rate of Return
µm	micrometer
kWp	kilo watt peak

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