Comparative Analysis of the Use of Different Energy Sources in the Operation of a Modern Tourist Facility

Marta SUKIENNIK[1)], Piotr PUCH[2)], Anna KOSMAN[3)]

[1)] PhD, DSc, Eng.; Department of Economics and Management in Industry, Faculty of Civil Engineering and Resource Management, AGH University of Krakow, Mickiewicza 30, Cracow, Poland; https://orcid.org/0000-0002-1882-1064, email: martas@agh.edu.pl
[2)] PhD candidate; Department of Economics and Management in Industry, Faculty of Civil Engineering and Resource Management, AGH University of Krakow, Mickiewicza 30, Cracow, Poland; https://orcid.org/0009-0006-3300-8035, email: puch@agh.edu.pl
[3)] Msc, Eng.; Poland; email: akosman@agh.edu.pl

http://doi.org/10.29227/IM-2025-01-12

Submission date: 28-04-2025 | Review date: 09-05-2025

Abstract

This article presents an analysis of the feasibility of using various energy sources for a newly developed tourist facility. The choice of an energy source is a strategic decision for any investor. Both economic and environmental factors must be taken into consideration. The analysis was conducted from both financial and environmental perspectives. Based on calculated energy demand, alternative energy sources were compared, including: natural gas (condensing boiler), geothermal energy, heat pump + PV, and pellet boiler. Calculations also included currently available funding programmes. Additionally, an environmental impact assessment was carried out. The findings serve as valuable guidance for investors, who should consider not only the financial dimension when choosing an energy source, but also the environmental impact, which has become a crucial element of today's decision-making processes.

Keywords: *renewable energy sources, sustainable development, geothermal energy, EU funding, tourism, investment*

1. INTRODUCTION AND OVERVIEW OF THE ISSUE

The strategic goal of a country's energy policy is to ensure energy security through the creation and provision of energy sources, changes in the methods of energy generation, and maintaining costs at a level that is economically and socially acceptable. Currently, several energy sources are available and widely used in Poland.

In the case of tourist facilities, the energy source plays a particularly significant role, as the structure of energy consumption depends on customers and represents a substantial cost burden. [4] One of the nationwide initiatives aimed at ensuring energy policy implementation is the development of energy clusters. It is worth noting that both academics and local government representatives recognise energy clusters as a crucial element in achieving the objectives of Poland's Energy Policy until 2040. The approach involves engaging local communities in the development of prosumer and decentralised energy generation, which helps reduce transmission and generation losses. Creating conditions that reduce the carbon footprint and protect the natural environment is also of vital importance. The energy cluster initiative also mitigates the risk of energy poverty and increases the share of renewable energy sources in the overall energy mix. Solutions are tailored to the local scale, thereby enhancing decentralisation, with a strong emphasis on research, development, and new technologies. [2]

The aim of this paper is to determine the most optimal energy source—both economically and in compliance with current environmental regulations—for powering a modern tourist facility. The decision-making analysis is carried out from financial, environmental, and regulatory perspectives. The subject of the analysis is a year-round tourist facility located in the southern region of Poland, scheduled to begin operation in 2027. Four solutions are considered: a condensing boiler powered by natural gas, the Podhale geothermal system, heat pumps with photovoltaic panels, and a pellet boiler. The work concludes with findings and recommendations for the case study.

The financial analysis includes investment costs, fuel/energy prices, and annual operating costs. The evaluation period is set to 15 years of building operation. The environmental analysis compares CO_2 and particulate matter emissions. In addition, regulatory factors, available subsidy programmes, and corporate image building must also be considered.

Choosing an energy source is a key issue for the investor—it forms part of a long-term business strategy and affects operational efficiency. The use of conventional energy offers lower initial costs, which may encourage entrepreneurs to choose this solution. Furthermore, conventional energy is often associated with stability—energy supplies are predictable and consistent.

However, reliance on conventional energy has a negative environmental impact and exposes businesses to fluctuations in raw material prices, which can substantially affect operating costs, particularly during global crises. Today, there is a growing awareness of environmental issues, and the transition to green energy is being supported by economic institutions in Poland and the European Union. These institutions offer a range of funding programmes for both private individuals and businesses.

In addition to regulatory and financial aspects, brand image building also plays a key role—implementing renewable energy sources often enhances the company's public perception, including among customers and business partners. Moreover, the decision to select an energy source is linked to energy independence—considering the volatility of global fuel prices and geopolitical uncertainty, this factor must not be overlooked.

2. SUBSIDY PROGRAMMES – OVERVIEW AND ANALYSIS

At present, numerous funding programmes are available, initiated by both the European Union and the Republic of Poland.

As of June 2025, applications are open for the "Mój Prąd 6.0" programme, which promotes and supports the installation of photovoltaic systems in households. It allows for reimbursement of up to 50% of eligible costs. Despite the current exhaustion of the programme's budget, the National Fund for Environmental Protection and Water Management is still accepting funding applications. The programme provides funding for classic PV installations, thermal and electric energy storage systems, PV carports and shelters, solar roof coverings, and balcony PV kits. [6]

Another programme supporting the use of green energy is "Czyste Powietrze". Its objective is to improve air quality and increase energy efficiency in buildings. Funding may be granted for the replacement of outdated boilers ("smokers - kopciuchy"), installation or upgrade of heating systems, replacement of windows and doors, or energy audits. The programme distinguishes between three levels of support, depending on income per person and corresponding funding percentages.

Two basic forms of support are currently available: direct subsidy and pre-financed subsidy. The former is provided by the Provincial Fund for Environmental Protection and Water Management and is paid in full or in up to three instalments upon submission of a payment request and relevant documentation. The pre-financed subsidy is available for the higher two levels of funding and allows partial payout before the investment begins. [3]

The "Moje Ciepło" programme is financed by the National Fund for Environmental Protection and Water Management and the EU Emissions Trading System (Modernisation Fund). It supports the installation of heat pumps in new or existing residential buildings. The aim is to promote prosumer energy systems in the area of air, water, and ground heat pumps. The budget amounts to approximately PLN 600 million. Funding is available in the form of subsidies covering up to 30% or 45% of eligible costs, depending on the type of pump installed. [5]

3. TECHNICAL PARAMETERS OF THE BUILDING

The analysed building is a year-round tourist cottage located in Zakopane. It is constructed with timber-masonry walls and fitted with high-efficiency windows (U-value = 1.0). The usable floor area is 61.88 m^2, while the total floor area is 84.25 m^2. The gross volume is 309 m^3, and the heated volume is 167.0 m^3. According to the project documentation, the estimated annual heat demand is approximately 15,000 kWh. The baseline energy source is natural gas, using a condensing boiler.

The building is oriented northward, with the main slopes of its gable roof facing east and west. The roof has a slope angle of 53°. Despite being located in a forested area in southern Poland, the building has full access to sunlight and is not shaded by trees or other structures.

4. CHARACTERISTICS OF ENERGY SOURCES CONSIDERED IN THE ANALYSIS

An unconventional energy source considered in the analysis is natural gas. The baseline project assumes the use of a condensing boiler for energy production. These types of boilers are considered more efficient due to their ability to recover heat from exhaust gases, unlike traditional boilers where heat is lost through the chimney. This translates into lower fuel consumption and reduced financial expenditure. It remains a popular heating method in Poland; however, due to its emissions, steps are being taken to phase out natural gas as a heating fuel. This is a long-term initiative, with a ban on the installation of new gas boilers in private buildings expected to come into effect from 2030. The broader energy policy is shifting towards increasing the share of renewable energy sources, ranging from hybrid systems to installations generating fully green energy.

Geothermal energy represents a highly promising, albeit still underutilised, solution. Naturally, the exploitation of this source requires favourable environmental conditions. Poland possesses significant geothermal potential, particularly in the Carpathians, the Lublin and Sandomierz Basins, as well as, in some cases, areas near large cities. Geothermal energy involves the extraction of Earth's internal heat for the production of both electrical and thermal energy. In the Podhale region, thermal water reservoirs are present, and the Podhale Basin itself forms part of the Central Carpathian Palaeogene Basin. The reservoir is recharged by the Tatra massif. While the initial investment costs for geothermal systems are high, it must be emphasised that this energy source is both emission-free and inexhaustible. Geothermal energy is characterised by several strengths: it is independent of weather conditions (a stable energy source), highly efficient, features low operating costs following installation, and can be used for both space heating and electricity generation [1]. A solution that is gaining in popularity is the combination of a heat pump with photovoltaic (PV) panels. A heat pump extracts heat from the surrounding environment (e.g., air) and transfers it into the building's heating system. This is a renewable energy solution with low emissions. PV panels, in turn, convert solar radiation into electricity. Of course, the effectiveness of this system depends on environmental conditions, such as the number of sunny days. Nonetheless, this is an environmentally friendly solution that also enables cost savings on energy bills.

It must be noted, however, that the amount of energy generated is dependent on weather conditions, making this solution less stable than conventional sources. Additionally, photovoltaic systems require regular cleaning and maintenance.

Pellet boilers are another source currently favoured by Polish households. Pellet is among the most environmentally friendly fuels, as its production is based on biomass. There are various types of pellet, though wood pellet is considered the most environmentally beneficial. Its utilisation is CO_2-neutral. It is produced from plant-based waste, such as sawdust or wood shavings, and exhibits high calorific value. While the upfront costs may be significant, the operational costs over time are lower compared to alternatives such as heating oil.

5. FINANCIAL ANALYSIS OF ALTERNATIVE ENERGY SOURCES FOR A MODERN TOURIST FACILITY

The financial analysis considers the size of the investment (including any available subsidies), the cost of fuel or energy, annual consumption, and annual operational costs. A 15-year operational period and an assumed inflation rate of 4% were adopted for forecasting purposes.

The actual annual thermal energy demand of the building was estimated at 14,393 kWh. To ensure calculation reliability,

Tab. 1. Financial comparison of alternative heating systems for a modern tourist facility (15-year period, 4% inflation)

Tab. 1. Porównanie finansowe alternatywnych systemów grzewczych dla nowoczesnego obiektu turystycznego (okres 15 lat, inflacja 4%)

Heat Source	Investment [PLN]	Fuel/Energy Price	Annual Consumption	Annual Operating Cost [PLN]	15-Year Cost with 4% Inflation [PLN]	CO_2 Emissions [t/year]
Natural Gas (Condensing Boiler)	30,000	0.44 PLN/kWh	14,349 kWh	~6,313	~169,000	~2.9
Podhale Geothermal Energy	35,000	0.27 PLN/kWh	14,349 kWh	~3,870	~72,000	~0
Heat Pump + PV (without subsidy)	95,700	~0 PLN/kWh (85% PV, 15% grid)	4,783 kWh	~2,500	~135,000	~0.47
Heat Pump with "Moje Ciepło" + "Mój Prąd"	59,700 (subsidy: 21,000 + 15,000)	~0 PLN/kWh	4,783 kWh	~2,500	~99,000	~0.47
Heat Pump with "Czyste Powietrze" + "Mój Prąd"	31,000 (subsidy: 49,000 + 15,000)	~0 PLN/kWh	4,783 kWh	~2,500	~70,000	~0.47
Pellet Boiler	16,000	1,800 PLN/t (3t/year)	16,880 kWh	~5,400	~123,000	~0 (biogenic)

Tab. 2. Annual CO_2 emissions and emission types for selected heating systems

Tab. 2. Roczne emisje CO_2 i rodzaje emisji dla wybranych systemów grzewczych

Heat Source	*Annual CO_2 Emissions [t]*	*Emission Type*
Natural Gas	~2.9	Direct (combustion)
Podhale Geothermal Energy	0	None
Heat Pump + PV	~0.47	Indirect (grid electricity)
Pellet	0	Biogenic (neutral)

in the case of systems with efficiencies below 100% (e.g., gas boiler), the energy demand was converted to primary energy required to produce the necessary amount of useful heat. The analysis also considered the efficiency of devices (e.g., COP for heat pumps) and the specific parameters of fuel and electricity consumption.

For the photovoltaic system, it was assumed that 85% of the energy would be generated onsite, with the remaining 15% drawn from the grid, reflecting typical PV production conditions in southern Poland (east-west orientation, roof inclination of 53°).

Based on the above table, the lowest annual emissions are observed for pellet boilers and Podhale geothermal systems. The highest emissions—directly released into the atmosphere—are generated by natural gas, which, while characterised by low particulate matter emissions, has high CO_2 output. Podhale geothermal energy is a renewable source with no local emissions and demonstrates excellent environmental cleanliness. The use of a heat pump combined with photovoltaic panels, assuming an 85% share of PV and 15% from the grid, constitutes a relatively low-emission solution. In the case of pellet boilers, CO_2 emissions are essentially neutral, as the carbon released during combustion is balanced by the CO_2 absorbed during tree growth. Nevertheless, it is important to note the potential for local emissions of particulates (PM2.5, PM10) and nitrogen compounds.

6. CONCLUSIONS AND RECOMMENDATIONS

The selection of an energy source for a tourist facility is a strategic decision for any investor. Both economic and environmental factors must be considered. Compliance with current legal recommendations and alignment with the growing trend of environmental awareness also positively influence the company's public image.

Based on the financial analysis conducted, the most economically advantageous options are the Podhale geothermal system and the heat pump (especially when available subsidies are taken into account). From an emissions perspective, the most environmentally beneficial solutions are again the Podhale geothermal system and the pellet boiler. However, the use of a heat pump combined with photovoltaic panels also constitutes a low-emission solution.

Considering current forecasts, which include a planned ban on new gas boilers from 2030, and assuming a 15-year operational period for the building, the choice of energy source narrows to the Podhale geothermal system and the heat pump with photovoltaic panels. These options offer the lowest total costs over the analysed period, despite their relatively higher initial investment costs. Taking advantage of available subsidy schemes—such as "Czyste Powietrze" and "Mój Prąd"—makes it possible to significantly reduce the investment cost of both heat pumps and PV installations.

From the investor's standpoint, following the above analysis—and in light of economic, environmental, and regulatory considerations—an investment in the Podhale geothermal system or a heat pump with photovoltaic panels appears to be the most favourable course of action. The condensing boiler fuelled by natural gas should be excluded due to its CO_2 emissions and the anticipated regulatory restrictions. The use of renewable energy sources enables lower energy bills and eliminates the negative environmental impact of the investment in terms of greenhouse gas emissions.

Literatura – References

1. Bujny, J., i in. (2024). Proces wdrażania i zastosowania odnawialnych źródeł energii w jednostkach samorządu terytorialnego: Analiza dla gmin z obszaru przyspieszonego rozwoju OZE. Instytut Innowacji i Odpowiedzialnego Rozwoju.
2. Bałamut, A., Gryz, J., Ruszel, M., & Szurlej, A. (2024). Rola klastrów energii w kształtowaniu samowystarczalności energetycznej i bezpieczeństwa na poziomie lokalnym w Polsce. KAPRINT (4).
3. Czyste Powietrze. (2025, June 10). Retrieved from https://czystepowietrze.gov.pl/
4. Global Compact Network Poland, Know-How Hub. (2024). Transformacja energetyczna w Polsce. https://ungc.org.pl/wp-content/uploads/2024/06/Transformacja_energetyczna_w_Polsce.pdf
5. Moje Ciepło. (2025, June 11). Retrieved from https://mojecieplo.gov.pl/O-Programie/#Cel-Programu
6. Mój Prąd. (2025, June 11). Retrieved from http://mojprad.gov.pl/

Analiza porównawcza zastosowania różnych źródeł energii w funkcjonowaniu nowoczesnego obiektu turystycznego

W artykule została przeprowadzona analiza możliwości zastosowania różnych źródeł energii dla nowopowstającego obiektu turystycznego. Wybór źródła energii dla obiektu turystycznego jest dla inwestora decyzją strategiczną. Należy brać pod uwagę zarówno czynniki ekonomiczne, jak i środowiskowe. Dokonano analizy zarówno w wymiarze ekonomicznym, jak i środowiskowym. Na podstawie obliczonego zapotrzebowana na energię, porównano alternatywne źródła energii, w tym: gaz ziemny (kocioł kondensacyjny), geotermia, pompa ciepła + PV, kocioł na pellet. Dokonano także obliczeń z uwzględnieniem dostępnych aktualnie programów wsparcia. Dodatkowo, wykonana została analiza środowiskowa. Wyniki badań stanowią źródło informacji dla inwestora, który powinien kierować się nie tylko wymiarem ekonomicznym przy podejmowaniu decyzji o źródle energii, ale także uwzględniać wymiar środowiskowy, który stanowi obecnie istotny element procesu decyzyjnego.

Słowa kluczowe: *odnawialne źródła energii, zrównoważony rozwój, energia geotermalna, dofinansowania UE, panele fotowoltaiczne, pompy ciepła, pellet, gaz ziemny, piec kondensacyjny, turystyka, inwestycje*