Acta Montanistica Slovaca
ISSN 1335-1788
actamont.tuke.sk

Optimizing the Utilization of Geothermal Water in Spa Tourism: An Investment Strategy with a Focus on Sustainability

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How to cite this article:
Tometzová, D., Molokáč, M. and Glova Végsőová, O. (2024). Optimizing the Utilization of Geothermal Water in Spa Tourism: An Investment Strategy with a Focus on Sustainability. *Acta Monstanistica Slovaca*, Volume 29 (1), 115-123

DOI:
https://doi.org/10.46544/AMS.v29i1.10

Abstract
The main subject of the paper is the effective utilization of geothermal water in a resort with the potential for spa tourism, linked to the proposal of an investment strategy. The primary objective is to suggest new development options for the destination, with a particular focus on the sustainability of the geothermal source. Two models for economic investment in area reconstruction are presented before the final proposal. The first model assesses the investment's effectiveness based on the Net Present Value (NPV), while the second model examines hydrological risks (such as a decrease in source capacity, water volume, and heat sources). This involves monitoring changes in water volume and heat sources over several years. The article's outcome aims to highlight, through a case study, the considerations for spa tourism resorts and potential risks associated with investment decisions, particularly in the context of the exhaustibility, volume, and quality of the geothermal water source.

Keywords
Geothermal Water, Spa Tourism, Economical Investment, Investment Strategy, Sustainability, Sustainable Reservoir

Introduction

Our Earth possesses both renewable and non-renewable resources, integral to our daily lives. Looking toward the future, there is a growing interest in renewable sources, considered the cleanest on Earth with minimal environmental impact (Seňová et al., 2022; Gupta & Sukanta, 2007). However, even renewable sources can face challenges like pollution, exemplified in geothermal water, as discussed by Simsek et al. (2000). The future prospects of geothermal energy hinge upon methodical and scientifically informed exploration and utilization of resources (Rohit et al., 2023). For this reason, the concept of sustainable development when utilizing geothermal water is crucial. The concept of sustainable development is founded on meeting the needs of current generations without jeopardizing the needs of future generations (Dincer & Rosen, 1998). According to Emas (2015), the primary objective of sustainable development is to ensure the enduring stability of both the economy and the environment. This can only be realized by incorporating and recognizing economic, environmental, and social considerations throughout the decision-making process. Agenda 21 (1992) and the Rio Declaration (1992) endorse the concept of sustainable development, which serves as a theoretical framework for attaining socially equitable economic development while safeguarding the natural resource foundation essential for human activities.

To avoid excessive extraction and use of geothermal energy, a concept of the sustainable geothermal reservoir has been developed (Axelsson et al., 2001), allowing for maintaining constant production for a certain period, at least 100 years. In Slovakia, the concept of a sustainable reservoir is relatively unfamiliar and novel. However, it is essential to begin incorporating modern sustainable engineering approaches within the framework of Slovak national assessment systems.

This article proposes a specific project utilizing geothermal water in a selected Slovak spa resort area. Analyzing the traditions of Thermo mineral water in spa and public spa resorts (Košić et al., 2011), the goal is to identify trends in the principles of sustainable geothermal water usage for tourism. The topic of sustainable production of geothermal energy and sustainable reservoirs has been previously discussed by Axelsson et al. (2001), Stefansson & Axelsson (2005), Rybach & Mongillo (2006), Fričovský et al. (2014), Tometzová (2014), and Gudmundsdottir & Horne (2020). In his study, Chandrasekharam et al. (2020) emphasized the significance of geothermal energy for sustainable water resources management. Moreover, various geophysical methods for studying geothermal water were explored by several authors like Hoover & Long (1974), Thanassoulas (1991), Georgsson et al. (2005), Ásmudsson et al. (2014) or Kana et al. (2015). While the studies mentioned above delved into hydrogeological research and optimizing geothermal water potential for tourism, economic models for implementing such projects were not explored.

The provided case study at Thermal Park Vrbov (Slovakia) introduces an investment model encompassing hydrogeological risks, along with economic and technical persistence models incorporating geothermal risks. Borović & Marković (2015) delved into the potential of geothermal water for heating, emphasizing its traditional balneotherapeutic purpose and tourism. Notably, the study aims to establish a new set of efficiency indexes suitable for resorts, hotels, and other accommodations. These indexes consider water supply, availability, planning, maintenance, and the intricate relationship between them and water consumption (Gössling, 2015). The results hold significance as they contribute to understanding and improving geothermal water utilization in various sectors, particularly within the context of tourism and hospitality.

Trends in Spa Tourism

In the realm of competition and the market, continual observation of trends and changes within tourism is paramount for gaining a competitive edge and establishing a leading position. These trends serve as defining factors for the direction and development of a spa resort. It is imperative for the spa resort to align its services with recent tendencies and client needs, as its success is intricately tied to fulfilling those needs and demands. However, while adapting to current trends, it is crucial to consider the focus of activity and ensure that services are offered in harmony with the indicative focus. According to Šindelářová (2018), the following trends in spa tourism can be identified:

- Nowadays, there is a trend towards shorter stays in spa resorts, in contrast to the past when spa treatments extended for 21 days (for adults) and 28 days (for children); today, options include one-week or five-day stays.
- A wellness stay is a recent trend, focusing on relaxation and beauty. As wellness has become a part of our lifestyle, these types of stays are becoming increasingly popular.
- Today, we also observe a change in the clientele interested in services, with more young people visiting spa resorts. This is the reason why these places must be adjusted to offer an active way of relaxation.
- Another continually growing trend is the connection of spa treatment with the gourmet experience, leading to a higher interest in "gastro-tourism".
- A different slowly developing phenomenon is tailor-made relaxation, including procedures made-to-measure, family stays, and senior stays.
- The offering of comprehensive services under one roof is becoming increasingly common due to popular demand.

The Slovak nation has become health-conscious, a trend closely tied to social, economic, and political changes. Notably, the escalating pollution of the Earth is a factor to consider. The development of spa tourism is influenced by the prevalence of lifestyle diseases among the population and advancements in medicine and natural sciences. Analyzing demographic trends in Slovakia, Europe and estimating the health conditions of the population, we can anticipate increased interest in specific products within spa tourism (Šindelářová, 2018). Presently, there is a significant focus on preventive care, acknowledging the impact of various negative factors such as depression, fatigue, increasing obesity, high blood pressure, and addictions to alcohol, drugs, and cigarettes (Haba, 2022).

Principles and Supply of Geothermal Water for Recreation and Tourism

The interest in using geothermal water is growing steadily, driven by the pollution of lakes and rivers—once dominant summer attractions – largely due to industrial and agricultural waste (Molokáč et al., 2007). Consequently, these traditional water bodies are becoming less suitable for tourism.

The use of thermal water for tourism is crucial, primarily due to its all-season potential (Franko, 1986). Moreover, the utilization of geothermal water in spa facilities acts as a pivotal factor in the socioeconomic development of a municipality (Kurek et al., 2020; Košić et al., 2011). Constructing thermal pools within existing resorts enhances the attractiveness of the location and its potential for year-round use, making it both effective and essential (Tometzová, 2012). Studies and observations indicate that the best results are achieved in areas that provide accommodation.

From both an economic and health perspective, it is essential to utilize water with the following characteristics:

- Temperature between 35 – 40°C;
- Well capacity exceeding 10 l/s;
- Mineralization up to 10 g/l with a suitable combination of salt and gases (Quattrini et al., 2017).

It is crucial to pursue a comprehensive approach to address the utilization of geothermal water for tourism, covering premises, urbanistic-architectonic conditions, technical solutions, maintenance, as well as economic considerations and model solutions for specific areas with thermal swimming pools (Franko, 1986; Košić et al., 2011).

Case Study Vrbov, Slovakia

The occurrence of geothermal water in the ground of Paleogene rock was investigated through two deep boreholes:

- Geothermal well VR-1 reached a depth of 1,742 m, drilling into Mesozoic rocks (crystalline dolomite) between 1,497 – 1,742 m. Hydrodynamic tests verified a yield of 28 l/s. The water temperature at a depth of 1,730 meters is 61.5°C, while at the mouth of the well, it registers 59°C.
- Geothermal well VR-2 reached a depth of 2,502 meters. During the drilling process, we identified the boundary line between the Inner Carpathian Paleogene and Mesozoic (Triassic – Choč nappe) at 1,488 meters, and the boundary line between Choč nappe and the Cretaceous Period (Neocomian), Krížna nappe at 1,951 meters. Subsequently, a source of middle hyperthermal water with a temperature of 63°C and a yield of 33 l/s was reached at the mouth of the well (Bergerová, 1997).

Investment Model with Hydrogeological Risks

Several companies invest in the build-up, reconstruction, and development of services, considering economic factors such as indexes that analyze the company's profitability, debts, economic return on investment, and more (Kráľovič & Vlachynský, 2006). Based on these economic indicators, a specific model has been developed to assess the effectiveness or ineffectiveness of the investment over the next seven years.

Economic Model of Durability

The net present value (NPV) model for Thermal Park Vrbov, Slovakia, was developed based on an analysis of expenses and income in 2014, utilizing the company's financial statement (Bergerová, 1997). An additional charge of 2% was taken into account for the next 7 years. The net present value was calculated from the input data, serving as an index indicating the economic return on investment. This method facilitates comparison between the current value of currency and the projected monetary value for subsequent years.

The table below (Table 1) illustrates all expenses and income for the year 2014, accounting for an additional charge of 2% (higher prices) for the following 7 years. The table provides a clear overview of the company's expenses, including repairs and maintenance, wage costs, material consumption, energy expenses, rent, commercials, and other fees related to fines, damages, etc. Thermal Park Vrbov offers paid services to tourists, resulting in an 'income' category that includes admission fees to the Thermal Park, income from lending and hiring sports equipment, income from selling refreshments, and more.

Table 1 Outline of Expenses and Incomes in Thousands of € for the Years 2014-2021

	2014	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Investment Expenses	*2, 182, 000*	-	-	-	-	-	-	-
Expenses Incurred on Cost of Goods Sold	*31, 568*	*32, 199*	*32, 843*	*33, 500*	*34, 170*	*34, 854*	*35, 551*	*36, 262*
Material, Energy Costs, and Other Measured Freight Supply Costs	*210, 257*	*214, 462*	*218, 751*	*223, 126*	*227, 589*	*232, 141*	*236, 784*	*241, 519*
Repairs and Maintenance	*154, 237*	*157, 322*	*160, 468*	*163, 678*	*166, 951*	*170, 290*	*173, 696*	*177, 170*
Services	*343, 788*	*350, 664*	*357, 677*	*364, 831*	*372, 127*	*379, 570*	*387, 161*	*394, 904*
Labour Costs	*293, 777*	*299, 653*	*305, 646*	*311, 759*	*317, 994*	*324, 354*	*330, 841*	*337, 457*
Other Actual Economic Costs	*11, 687*	*11, 921*	*12, 159*	*12, 402*	*12, 650*	*12, 903*	*13, 616*	*13, 425*
Total Expenses	*1, 045, 314*	*1, 066, 220*	*1, 087, 545*	*1, 109, 296*	*1, 131, 481*	*1, 154, 111*	*1, 177, 193*	*1, 200, 737*
Revenue from the Sale of Merchandise	*66, 458*	*67, 787*	*69, 143*	*70, 526*	*71, 936*	*73, 375*	*74, 843*	*76, 339*
Revenue from the Sale of Own Products	*19, 230*	*19, 615*	*21, 576*	*23, 734*	*26, 107*	*28, 718*	*31, 590*	*34, 748*
Revenue from the Sale of Services	*1, 644, 196*	*1, 677, 080*	*1, 844, 788*	*2, 029, 267*	*2, 232, 193*	*2, 455, 413*	*2, 700, 954*	*2, 971, 049*
Total Income	*1, 729, 884*	*1, 764, 482*	*1, 935, 507*	*2, 123, 526*	*2, 330, 237*	*2, 557, 505*	*2, 807, 386*	*3, 082, 137*

During the evaluation of the investment project's income return, the net operational income was considered, while for the net present value, the investment over a period of 7 years was taken into account. Net operational income is the difference between operational income and expenses (Table 2).

Table 2 Profit of the Company (Net) in Thousands of € in Years 2014-2021

Net Operating Income								
Finances/Year	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Operating Expenses	*1, 045, 314*	*1, 066, 220*	*1, 087, 545*	*1, 109, 296*	*1, 131, 481*	*1, 154, 111*	*1, 177, 193*	*1, 200, 737*
Operating Income	*1, 729, 884*	*1, 764, 482*	*1, 935, 507*	*2, 126, 526*	*2, 330, 237*	*2, 557, 505*	*2, 807, 386*	*3, 082, 137*
Net Operating Income	*684, 570*	*698, 261*	*847, 962*	*1, 014, 231*	*1, 198, 755*	*1, 403, 394*	*1, 630, 193*	*1, 881, 400*

To calculate the present value, the formula employed was:

$$NPV = \sum_{i=1}^{N} P_n \frac{1}{(1+i)^n} - K \tag{1}$$

Where:

P – Income in the form of money from investment in the following years of durability
n – individual years of durability
i – interest rate (interest in %/100)
K – investment expenses

To calculate NPV, Table 3 below was utilized to assist in determining the current value interest factor (CVIF). In the NPV calculation, a 10% discount rate was utilized, a common practice in similar projects.

Table 3 Calculation of NPV With The Use of CVIF

Year of Durability	*Income* P_n	*Discount Factor* $1/(1+i)^n$	*Discounted Income* P_n* *Discount Factor*
1	*698, 261*	*0.90909*	*634, 783.09*
2	*847, 962*	*0.82645*	*700, 795.20*
3	*1, 014, 231*	*0.75131*	*762, 006.42*
4	*1, 198, 755*	*0.68301*	*818, 765.93*
5	*1, 403, 394*	*0.62092*	*871, 397.46*
6	*1, 630, 193*	*0.56447*	*920, 201.25*
7	*1, 881, 400*	*0.51316*	*965, 455.67*
Σ	*8, 674, 196*		*5, 673, 405.03*
NPV			*729, 353.85*

In evaluating the investment intention, consideration was given to the net present value (NPV), which is influenced by the discount rate, incorporating the interest rate. The higher the discount rate, the lower the value of NPV in the project. Since this value is almost unpredictable, stating the discount rate is a drawback of the chosen method.

Based on the given data, the NPV value was positive. Consequently, it was concluded that the project is viable and acceptable under the current conditions, as the projected income over the investment's duration will cover all costs and yield the desired profit. The positive value also indicates that the investment project ensures long-term sustainability and functionality. The project is expected to be profitable, meaning it should generate more revenue than the initial investment sum.

The ultimate NPV value serves as a metric for estimating the company's potential earnings over the investment period or the prospective increase in the company's valuation.

Technical Model of Durability With Geothermal Risk

A model assessing the effectiveness and functionality of the investment was developed using Thermal Park Vrbov (Slovakia) as a case study. However, it is essential to emphasize the need to examine this matter from a hydrogeological perspective, as these parameters introduce certain risks to the investment.

Considering the average thickness of a group of strata, the average thickness was defined as z = 450 m, while a thickness of z = 225 m is accounted for, representing 50% of the average thickness of the reservoir area.

The area A = 43 km² was defined based on the research conducted by Franko et al. (1995). The author utilized the results of geophysical work, allowing him to define the tectonic boundary in the form of a fault (Figure 1).

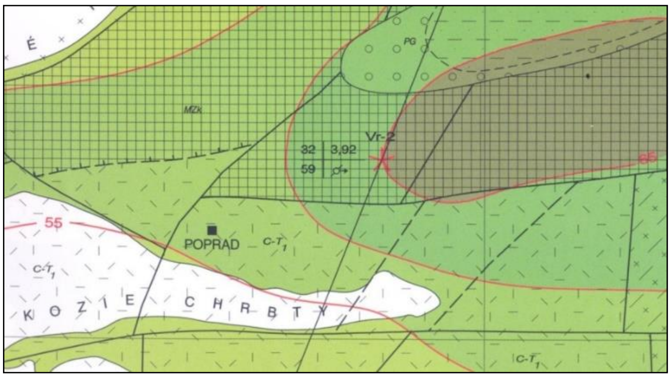

Fig. 1. Map depicting a segment of the geothermal structure within the Levočská basin at a depth of 2000 meters, focusing on the VR-2 geothermal well located in Vrbov [Franko et al., 1995]
Map explanations: PG – Paleogene (Inner Carpathian), consisting of sandstones and claystones (Zuberec and Hutian formations); MZk – Mesozoic (Krížná nappe), comprising limestones, dolomites, slates, quartzites, marls, sandstones, and marly limestones; C-T_1 – Carboniferous to Lower Triassic (Ipoltic Group - "melaphyre series"), characterized by variegated shales, sandstones, arkoses, conglomerates, phyllites, melaphyres, and tuffs; 55, 65 - temperature values at a depth of 2000 m [Franko et al., 1995]

Average rock porosity is 3%, rock density ρ_r = 2,750 kg/m³, water density ρ_w = 982.253 kg/m³, thermal rock capacity c_r = 900 J/kg·K, thermal water capacity c_w = 4,191 J/kg·K, temperature of reservoir T_0 = 62 °C, reference temperature T_{ree} = 21 °C, temperature at the mouth of the bore T_{wh} = 56 °C.

Calculation of Proven Sources Rprov

$$R_{prov} = Q * \left(T_{wh} - T_{ref}\right) * c_w = 9.45909\ MW \tag{2}$$

1. Calculation of the Production of Geothermal Energy E_t

$$E_t = A * z[(1 - \emptyset) * rhor * c_r + (rhow * c_w *)] * \left(T_{rez} - T_{ref}\right) = 7{,}22161E + 16J \tag{3}$$

Calculation of Probable Reserves

$$R_{pb} = E * R \div t\ [MW] \tag{4}$$

2. Calculation of Sustainable Amount of Water r_{cap}

$$r_{cab} = R_{cab} \div R_{pb} \tag{5}$$

$$R_{cab} = R_{pb} - R_{prov}\ [MW] \tag{6}$$

3. Calculation of Balance Amount of Water Q_{cyn}

$$Q_{cyn} = Et * R \div \left(T_{wh} - T_{ref}\right) * c_w * rhow * t \quad [m^3/s] \tag{7}$$

4. Calculation of the coefficient of reserves capacity

The capacity of the reservoir reserves can be determined by:

$$R_{cap} = R_{prob} - R_{prov} \tag{8}$$

Consequently, the ratio of unused energy (reserves capacity) to the total energy of the reservoir defines the coefficient of the reserves capacity:

$$r_{cap} = R_{cab}/R_{prob} \tag{9}$$

According to the results of the coefficient of source capacity, the following classification table was prepared, defining 4 conditions for sustainability (Table 4):

Table 4 Classification Table for Evaluating Sustainability Based on the Capacity Share of Sources [Bjarnadottir, 2010]

r_{cap} ratio	***Sustainability classification***	***Sustainability description***
r_{cap} < 0	*Massive overexploitation*	*over-use of the resources*
r_{cap} 0-0.49	*Overexploitation*	*more than a half of the resources are used*
r_{cap} 0.5-0.74	*Sustainable production*	*less than a half of the resources are used*
r_{cap} 0.75-1	*Highly sustainable production*	*longterm sustainability*

In Figure 2, proven energy sources are depicted and categorized according to probable sources within the time interval from 0-300 years. The graph consists of 3 lines: the red line represents proven sources with a coefficient of capacity of 0.1, the blue line represents proven sources with a coefficient of capacity of 0.5, and the green line represents proven sources with a coefficient of capacity of 0.75.

The graph (Figure 2) illustrates that when the coefficient of source capacity equals 0.1, the value of proven energy sources is 8.24 MW after 25 years and 0.69 MW after 300 years. If the coefficient of source capacity equals 0.5, the value of proven energy sources is 4.58 MW after 25 years and 0.38 MW after 300 years. The coefficient of source capacity 0.75 shows the value of proven energy sources as 2.29 MW after 25 years and 0.19 MW after 300 years.

The lowest production is observed with a coefficient of sources capacity (r_{cap}) equal to 0.75 after 125 years, indicating that more than half of the sources have been used, approaching resource depletion.

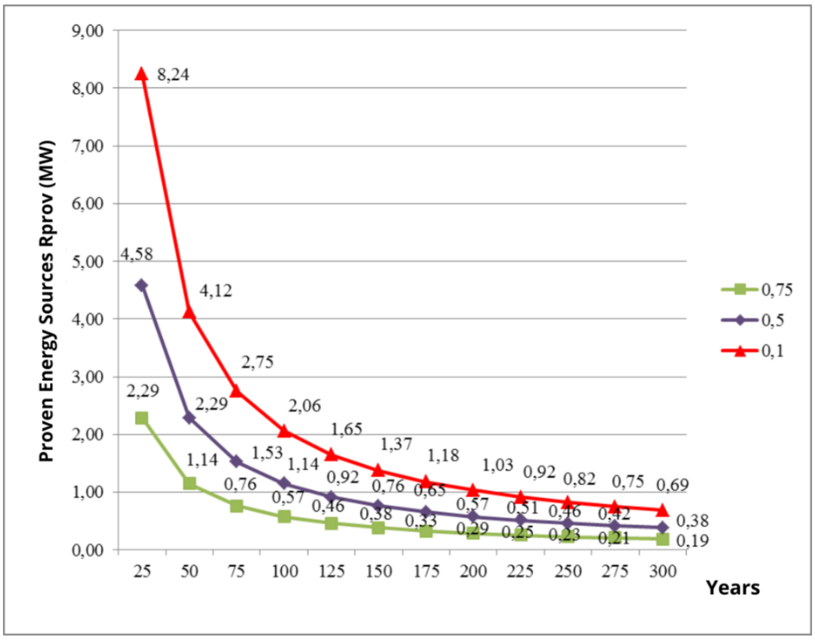

Figure 2. Proven Energy Sources Calculated from Probable Sources

In the following graph (Figure 3), proven sources' volume of water or capacity is depicted within a time horizon of 0-300 years. The graph comprises three lines: the red line represents proven sources with a coefficient of capacity of 0.1, the blue line represents proven sources with a coefficient of capacity of 0.5, and the green line represents proven sources with a coefficient of capacity of 0.75.

Figure 3 illustrates a decrease in the sources over the time interval for all three lines. If r_{cap} = 0.1, the value of proven sources equals 57.22 l/s in 25 years and 4.77 l/s in 300 years. For a coefficient of capacity of sources equal to 0.5, the value of proven water sources is 31.79 l/s in 25 years, and in 300 years, it is 2.65 l/s. The coefficient of capacity of sources 0.75 shows the value of proven sources of energy as 15.89 l/s in 25 years and 1.32 l/s in 300 years.

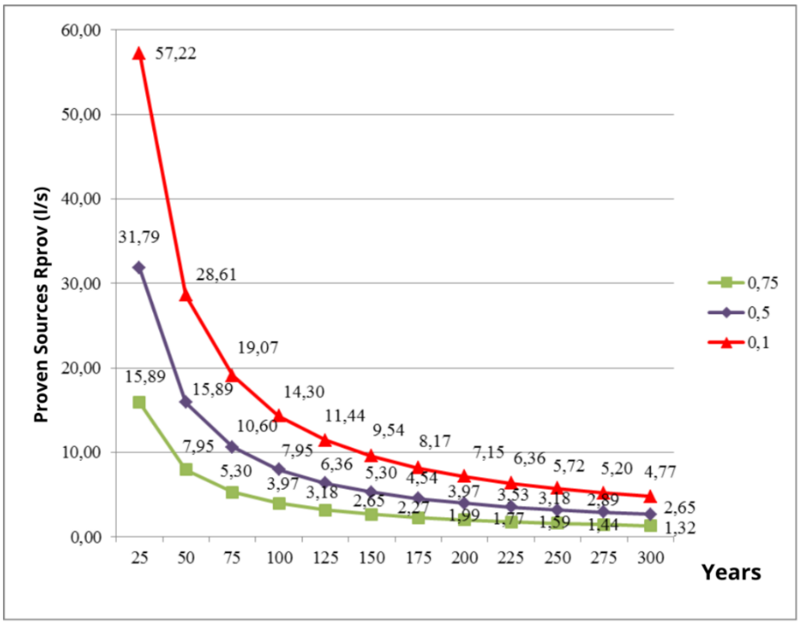

Figure 3. Proven Sources of Volume of Water Calculated by Balance Amount of Water (0-300 years)

Conclusion

According to internal data from SALMOTHERM - Invest, s.r.o. in Vrbov, the minimum volume of water required for daily operations is 3,264 m³, which is equivalent to a flow rate of 37.7 l/s. Based on the depicted water sources in Figure 3, a reduction in water sources to 37.7 l/s is projected to occur after 42.16 years. This model highlights the potential risk of declining water sources and other associated risks in the Thermal Park investment. The analysis indicates that the potential decrease in the balance of water sources to a minimum for operation will occur in approximately 42 years at the current consumption rate. However, both the capacity, whether in terms of balance or energy, appears sufficient for the upcoming years.

The investment in the project remains effective even when considering hydrogeological risks, as indicated by our results of proven sources for at least 7 years without any decrease. The short-term view of both models shows the investment's effectiveness during the Thermal Park's reconstruction within 10 years, with no substantial decrease in the balance amount of water or estimated energy sources. However, over a longer time horizon, there is a potential risk that must be taken into consideration. The identified risk could be addressed by considering alternative solutions, such as the implementation of a water tank for regeneration. While this may introduce some challenges and potential negative impacts on the investment, it represents a feasible strategy to mitigate the long-term hydrogeological risk. Furthermore, additional alternative solutions not addressed in this paper may necessitate further exploration to ensure the sustained success of Thermal Park Vrbov.

In essence, the findings underscore the importance of ongoing monitoring, adaptive management, and a proactive approach to address potential challenges in the evolving landscape of any thermal spa investment. By embracing sustainable practices and exploring innovative solutions, stakeholders can navigate potential risks and secure the long-term viability of impactful geothermal projects in spa areas.

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