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# MEANS OF USING LOW-POTENTIAL GEOTHERMAL ENERGY FOR RECREATIONAL PURPOSES IN THE KOŠICE REGION

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***Keywords:*** heat pump, geothermal energy, hydrogeology
***Abstract:*** The authors focused on the possibility of using low-potential energy from groundwater by means of heat pumps in the Košice region for recreational purposes as an alternative to geothermal energy obtained from large depths. The article deals with the hydrogeological suitability of the Košice region territory for the use of water-water heat pumps, suitable technical works in the digging of wells as prepare exploitation well and re-injections well, and outputs, while also trying to point out the economics benefits of using low-potential energy from groundwater against to geothermal energy obtained from large depths.

## 1 Introduction

Nowadays, geothermal energy is used for recreational and medical purposes, mainly obtained from geothermal wells reaching a depth of about 2500-3000 m in diameter. This is necessary due to the geothermal gradient, which reaches up to 1°C at 30 m of the drilling depth in most of the territory of the Slovak Republic. For example, some territories in Hungary, where the use of geothermal energy for recreational and medical purposes is already a long tradition, achieve a geothermal gradient of 1°C to 20 m and, in some exceptional cases, 1°C to 15 m, which in practice means that it does not require to be drilled to depths like in our area. This is mainly due to the appropriate geological structure of the area. Of course, it must be water-borne horizons, because water is a medium that ensures the transfer of thermal energy from large depths to the surface. This must be preceded by a rigorous geological survey. All this means huge costs to the exploration itself, as well as to the drilling and replacement of mining and cooling systems, and so on. Under our conditions, the price of 1 bm of a borehole in deep boreholes varies between 1300 - 1650 €, which is about 3,000 m deep drilling about 4,5 - 5,0 mil. €. At such a depth it is possible to obtain water at a temperature of about 90-100 °C [1][2].

As a suitable alternative, we can see the possibility of using low-potential geothermal energy from quaternary groundwater, ie from relatively small depths, where there is sufficient yield of these groundwater, even though this groundwater reaches temperatures in the range of 10-12°C. However, even with such low temperatures and sufficient efficiency, it is possible to use thermal water pumps using water-water heat pumps to obtain thermal water at high-temperature heat pumps up to 65°C, which should very well cover the water temperature requirements for recreational and medical purposes. Basically, the water temperature for these purposes ranges from 26°C to 40°C. Of course, the excess heat obtained can be used for heating purposes as well as heating of domestic water..

The advantage of using heat pumps is also the fact that during the summer months it is not necessary to push the cooled water at the outlet from the heat pump into the intake wells, but it is possible to use this water at a temperature of about 5°C - 7°C to cool the interior spaces, in fact, it will be actually air conditioning. It is worth mentioning that the power of the high-quality pumps is about 35% in relation to the power, which is a huge advantage over conventional gas heating, respectively electricity [3].

## 2 Hydrogeological proportions in the Košice region

The hydrogeological examination of the part of Košice basin is fairly even. Most of the exploration work and evaluation was concentrated here on the groundwater of quaternary collectors and, to a lesser extent, on neogene sediments. The entire studied area is a part of the territory shown on the page 38 Kosice baseline hydrogeological map of scale 1: 200,000 [4] and underground water chemistry maps at the same scale. Textual explanatory notes to the basic hydrogeological map were prepared by Škvarka et al. [5]. The basic data on hydrogeology of quaternary sediments in the assessed area were provided by the work of Struňák [6], Šindler [7], Ondizkova [8] and Frankovič [9]. Later on, Halešová et al. [10,11] discussed this issue. A valuable regional summary of the findings is also provided by Šindler et al. [12] and Halešová with Petrivaldský [13], in which numerous local works are summarized. From a hydraulic point of view, the region of


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Košice basin as a whole was evaluated by Jetel and Kaličiak et al. [14].

The area under assessment is the hydrogeological region Q 125 - the Hornad quaternary in which two sub-areas HD-10 and HD-40 are allocated.

From a hydrogeological and structural perspective, the territory consists of a layer of water in the sedimentary collectors of the quaternary.

The uppermost part of the sediments consists of flood plains with a thickness in the range of 0.4 - 2.6 m. From the flow and accumulation of groundwater point of view, the layer of sandy gravel with a thickness of 3.3 to 11.7 m is the most important. The groundwater level at the time of drilling was most often found at a depth of about 2.0 m. A greater number of hydrogeological boreholes are concentrated between Košice and Čaňa, whose maximal values of substantiality [15-17], are from 0.3 to 25.0 $l.s^{-1}$. Some of these wells are used partly as local drinking water sources.

Towards the west, in further distance from Hornád, there is a territory that is part of the HD 20 partial terrain (Hornád terraces). Their lithological composition is more varied than sediment in the valley, mainly due to the more frequent presence of the sand fraction, whether in clay or gravel. The topmost layer of slats does not exceed 1.2 m. The drained collector also includes sandy gravels with an average thickness exceeding 10.0 m. The groundwater level is at greater depths (5.24 - 6.8 m p. T). Earlier exploratory work [10] confirmed the general knowledge of the low usability of groundwater from this environment. The average yield per one well does not exceed 2.0 $l.s^{-1}$ [17].

Findings about the possibility of acquiring larger amount of groundwater have also yielded research work [15] aimed at deeper (50 to 150 m) layered gravel and sandy strata of neogen. This is the so- artesian horizons (wells with a positive groundwater level passing through their discharge), in which the yield per one bore is more than 10.0 $l.s^{-1}$.

## 3 Evaluation of means of acquiring groundwater for given purposes

Based on the above-mentioned knowledge of the hydrogeological ratios of the area of interest, it can be stated that the area of interest in considering the use of groundwater for the operation of heat pumps has very good assumptions in this respect.

In the territory of the southern outskirts of Košíc, several boreholes have been carried out to verify the quantity and quality of groundwater, focused on shallow quaternary sediments, as well as on deeper deposited neogene layers. The parameters of the boreholes in question are given in the following Table 1.

In order to ensure the operation of water-water heat pumps with an approximate output of about 1 MW, approximately 35 $l.s^{-1}$ will be required from the specified area. This would be possible to achieve 3-4 farm wells and the same number of wells. In order to provide a water source for the normal operation of the necessary equipment, one water well (well) of about 10 $l.s^{-1}$ should be sufficient, but it is also necessary to consider the appropriate reservoir - reservoir of a water source in order to meet the hygienic standards. The location of the individual wells should be consulted with the prospective designer. The distances between the individual wells should range from 40 to 50 m in order to avoid the possible influence of the individual wells in terms of their yield and possibly possible cooling [19].

*Table 1 Characteristic data hg boreholes*

| **Borehole Marking** | **Borehole Depth** h [m] | **Water Temperature** t[°C] | **Richness** $Q[l.s1^{-1}]$ |
|---|---|---|---|
| **VS-9** | 8,0 | 12,0 | 1,42 |
| **VS-10** | 8,7 | 11,0 | 7,14 |
| **VS-12** | 10,2 | 12,0 | 2,32 |
| **VS-13** | 8,5 | 11,0 | 7,60 |
| **VS-14** | 8,5 | 13,0 | 7,60 |
| **VS-15** | 8,5 | 13,0 | 14,20 |
| **VS-15** | 8,2 | 12,0 | 3,30 |
| **KAH-6** | 163,6 | 16,0 | 14,47 |

## 4 Design of suitable heat pump system

Modern electric heat pumps today are an exceptionally ecological option for heat generation. Advanced control systems, efficient compressors as well as sophisticated serial production ensure that modern heat pumps from one piece of electrical current produce up to five parts of heat. Heat pumps can provide heat production monovalently, that is without an additional heat source. Operating costs are significantly lower than conventional heating equipment, which compensates for higher investment over a relatively short period of time. In terms of reliability, unlike in recent years, these devices meet the strictest requirements [20].

For the sake of clarity we will model the use of a cascade-coupled heat pump system. This could be a 3-piece York-Johnson Controls YLCS water-water heat pump of 350 kW (Figure 1), which would mean a maximum output of 1050 kW. Cascaded plugging is more cost-effective, increasing operational reliability of the entire device.


*Figure 1 York Johnson Controls: model YLCS of 350 kW*



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To predict water heating in pool areas, we try to model the need for heat supplied by the heat pump system. Since we do not know exactly how much water will be heated, we will try to process several variants. We expect the average depth in pools of 1m and an area of 500m$^2$, 1000m$^2$ and 1500m$^2$. The required temperature in pools where the water will be heated is assumed to be 38˚C. It should also be said that these heat pumps can be used at the same time in addition to the heating of water and heating, as well as cooling, that is, the air conditioning used in the summer months. Of course, the combination of solar thermal collectors, which can have a great impact on the reduction of power, especially during the summer months between March and October, will also be a suitable addition to the water heating.

## 5 Determination of the energy balance for pool water heating

Pools in thermal swimming pools are most often filled with water with 27-40°C, which is produced by mixing hot water with cold water in such a proportion as to achieve the required pool water temperature. The filling time depends on the capacity of the water sources. Full water exchange in swimming pools with a flow system takes place within short periods of time (1 – 7 days).

Pools are normally filled at night to avoid interrupting the operation of pools. For this reason, it is preferable to build several smaller pools instead of one large. When replacing water with a non-circulating filler system, the pool swells at the beginning of the season and then complements it, which significantly reduces the demand for both hot and cold water. Water recirculation is considered to be the most perfect way of replacing water in which a certain amount of water is pumped out and recirculated through the filtration plant. The treatment plant must have sufficient capacity resulting from the volume and intensity of the recirculation. The intensity of recirculation is determined by the theoretical time of water retention in the pool and is expressed in hours relative to the average depth of the pool.

The dimensioning of the energy needed to heat the pool water influences to a large extent the swimming pool type (outdoor, indoor), the required parameters of the pool water, the method of limiting the heat losses of swimming pools. The design envisages outdoor, open swimming pools with year-round operation, without hiding pools. The design will be made for pools with a temperature of 36-38 °C and a total pool area of 800, 1000, 1300 and 1500 m$^2$ and therefore at a water depth of 1m with a volume of 800, 1000, 1300 and 1500 m$^3$. Climate and weather conditions of the site are taken into account.

For pool water heating, it is necessary to supply heat for:

- heat loss management by transfer of water level (heating, flow, evaporation),
- heat loss by heat transfer through the swimming pools walls (below water level),
- heating of supplied fresh water (compensation of water loss - spraying, carrying on swimmers' bodies, water for filter cleaning).

Thermal losses due to the pools walls are negligible and therefore are not considered in this proposal. In the energy balance of the pool heat, we also take into account the heat gains that may be the source of direct sunlight.

The determination of the pool's energy requirements is carried out for all months of the year. Inputs are included: Air temperature for individual months, Soil temperature, Air temperature at sunshine, Theoretical sunshine duration, Relative air humidity, Amount of sunlight that falls on m$^2$ of water surface.

Output is the amount of heat the pool loses during the month and needs to be labeled as Heat requirement to cover losses and the amount of heat needed to heat the incoming clean water indicated as Heat requirement for cold water heating. The overall heat demand is the most important indicator and output of the following tables. The heat requirement per m$^2$ of surface area is a control indicator. In our conditions it reaches values ranging from 0.4 to 1.4 kW.m$^{-2}$.

The design contemplates heat pumps with an effective power figure of about 3.5, i.e., the heating power of the appliance is 3.5 times higher than the power input required for the heat pump operation. The amount of heat that would be able to supply 3 heat pumps with a heating output of 350 kW is around 756 MWh per month. Calculation example:

3 x 350 kW = 1050 kW...total power of all three heat pump

1050 kW x 24 h = 25 200 kWh…total power of all three heat pump per hour

25 200 kWh x 30 = 756 000 kWh (756 MWh)…total power of all three heat pump per month

This amount of heat would be supplied by heat pumps in case they would work 24 hours a day with a 100% efficiency. In fact, the heat supply would be somewhat lower.

## 6 Conclusion

At the given input values, when considering the natural conditions in Košice region, water temperature 38 °C, open swimming pool, three heat pumps with heating capacity around 3x350kW, it is possible to count with year-round operation if the surface area of less than 800 m$^2$ and depth 1m. All of these suggestions are based on assumptions that contribute to the higher overall heat demand to be delivered by heat pumps. Because open pools are assumed, it is wise to consider covering water at a time when pools are out of service, which would greatly reduce losses (up to 50% loss by evaporation). It is appropriate to divide the pool area



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into pools with different volumes and water temperatures. Water temperature 36-38°C is over expressed, increases energy demands and also affects the occurrence of microorganisms in water. Each decrease in the water temperature in the pool by several °C contributes to the higher utilization of the intended heat pumps and to the higher economic efficiency of the swimming pool area.

From the individual chapters, it is clear, that the use of low-potential geothermal energy for recreational and medical purposes is possible and economically more advantageous than the use of geothermal energy.

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