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GEOTHERMAL ENERGY UTILISATION IN SLOVAKIA AND ITS FUTURE DEVELOPMENT

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ABSTRACT

Due to favourable geological conditions Slovakia is the country rich in low enthalpy sources occurrences. The state policy support new renewable ecological energy sources, among which the geothermal energy belongs. The geothermal water is used for recreation (swimming pools, spa), agriculture (greenhouses heating, fishery) and district heating. The efficiency of geothermal use is about 30 % because of seasonal utilisation. Therefore the district heating and hot water supply from geothermal water for the annual operation is supported. Slovgeoterm Company implemented in last years greenhouses heating in Podhajska and heating of hospital and 1231 flats in Galanta. At present has been started investigation for the biggest geothermal project in Central Europe – Kosice basin construction.

1. INTRODUCTION

To cover the energetic demands of Slovakia, the economy depends on energy import. Therefore the state tends to use non-traditional new renewable energy sources which are ecological. The energetic potential of these sources represent about 4 % of the primary energy sources usable in 2005 resp. 2010, i.e. about 40 000 TJ/y. Up to now the utilization of the geothermal energy is very low but conditions for utilization of 180 MW before 1999 year are being created. Geothermal energy represents 18% of these energetic non-traditional sources (M.Racicky, 1997). The energetic conceptions of Slovak Republic suppose the utilisation of 5200 MW_t of total potential usable geothermal sources. The present state of knowledge are summarised in Atlas of Geothermal Energy of Slovakia (O.Franko et al., 1995) where the usable energy sources represent 5553 MW_t. The renewed part of that amount is 553 MW_t and unrenewed part is 4985 MW_t. It is obvious that the real usable geothermal sources would be lower than mentioned above. Geothermal water is used on 35 localities mainly for recreation and agricultural purposes, less for district heating. There is 83 MW_t utilised as the whole with low efficiency (about 30 %) due to seasonal use. Slovgeoterm Company implemented and developed the geothermal energy utilisation in Podhajska, Galanta and started work on Kosice district heating project (Fig.1).

2. GEOTHERMAL UTILISATION LOCATIONS

2.1. Podhajska greenhouses heating

Podhajska is situated about 90 km eastern from Bratislava, in north-eastern part of Danube basin. From geological viewpoint the area is called Levice block, which is one of 26 Slovak hydrogeothermal structures. The Neogene rocks in basin overlie the Middle Triassic dolomites and Lower Triassic quartzites of Choc and higher nappes. The Mesozoic rocks, mainly Triassic dolomites, form the geothermal aquifer of highly mineralised water. In Podhajska by well Po-1 drilled in 1973 the remarkable Na-Cl type of geothermal water with 19 g/l TDS was found. Since 1973 the well Po-1 was exploited for greenhouses and recreational purposes. Because of environmental rules and pressure drop in the well the reinjection well GRP-1 was drilled. It is situated 2000 m NE from Po-1 and it is 1470 m deep. The Triassic dolomites, limestones and dolomitic breccias have the porosity in range 0,6 – 4,15 %. The seasonal free flowrate of the well Po-1 is 45 l/s of 82°C water, but the average annual flowrate of the well is 20 l/s. In the reinjected well GRP-1 the whole produced flowrate is reinjected i.e. 45 l/s during season, the reinjected temperature is 45°C (Vana and Bondarenkova, 1995). The reinjection system schema is in Fig.2. The energy delivery is 102,9 TJ/year, the heat output of the well is 12 MW. The probable thermal energy potential of the geothermal waters in Levice block is 126,14 MW_t. The project in Podhajska is focussed on greenhouses heating in area of 2 ha via heat exchangers. The geothermal water pass through heat exchangers and further through poly-propylene pipe. Building of the exchange station has been based on mounting of three plate exchangers with titanic plates, each of them having exchange heat capacity of 3,5 MW, and their overall capacity being 10,5 MW. The exchangers were delivered from France firm VICARB. The whole system has been completed with gas separation, pump blocks and control and treating systems of circulation water. Electromagnetic protection against scaling has been built between separator and heat exchanger with significant effect. The treatment with scale inhibitor is still continuing for the reason of well protection and so as treatment with corrosion inhibitor for protection of pipes downstream to heat exchangers, where pH value is lowered. (Vana and Franko, 1997). The whole solution has proved as successful and enabled to redouble the greenhouse area and thus agricultural production (vegetable raising). At the same time the environmental problem with water disposal has been solved by reinjection of the water into formation with long-term supporting of formation pressure.

2.2. Galanta district heating

Galanta town is situated in the southern part of Slovakia, in Gabcikovo geothermal structure, which is the part of Central depression of Danube basin. The geothermal water occur in Pontian and Pannonian sands in depths 900 – 3000 m. The geothermal water temperature range in 40 – 90 °C, flowrate of the well range in 7 – 20 l/s. The chemical composition of the water is Na-HCO_3 to Na-HCO_3 – Cl type with TDS 7 g/l. The geothermal water of the area are mainly used for swimming pools and in agriculture (greenhouses heating), less for energetic purposes.

On the base of 2 geothermal wells FGG-2 and FGG-3 the geothermal heating project was set in Galanta.

The total flowrate of the wells is 50 l/s and wellhead temperature 78°C. The wells are used seasonally and alternate in utilisation for recovering the other one. In project of flats the utilisation of geothermal energy was considered – the heat distribution network was dimensioned for geothermal heat. Because of the finances lack the conventional heating centre was constructed. In 1996 the geothermal station operated by Galantaterm ltd. with financial support of Slovak gas industry, Galanta town, Slovgeoterm, NEFCO Helsinki and Hitaveita Reykjavik was constructed. The geothermal energy provide heating of 1236 flats in "Sever" quarter, complex of Regional Hospital buildings and House for retired people. The energetic potential of 8 MWt is supplied from 2 geothermal wells FGG-2 and FGG-3. The geothermal energy cover district heating and hot water supply as well. In case that the outside temperature decreases to –2°C and more, the gas is used to cover heat lack. The payback time is calculated to 7 years according to cash-flow calculation done in Iceland. The construction of geothermal station put out of operation the classic coal energy source what has a remarkable ecological effect. The emission of 330 t SO_2, 159 t CO_2 and 600 t slag were eliminated. The operation of geothermal station diminished the gas consumption to 1,2 mil Nm^3/year that means 60 % lower emission compared to previous state. The geothermal energy cover about 80 % of annual energy demand (M.Racicky, 1997).

2.3. Kosice basin

2.3.1. Investigation of the Durkov geothermal structure

At present the biggest geothermal heating project in Central Europe with installed heat output of 110 MW will be situated in Eastern Slovakia – Kosice basin. The Durkov geothermal structure location, which lies in depression of Neogene basement, is about 15 km eastern from town Kosice. The results of three geothermal investigation wells drilled in 1998 – 1999 confirmed the presence of geothermal reservoir with heat potential at least 100 MW_t. The area was investigated by three investigation oil drills – Durkov 1, 2, 3 drilled 1968 – 1972. Geothermal water inflows were confirmed by DST tests. Source of geothermal water occur in Triassic dolomites, mainly in the upper part on contact with Neogene overlying rocks. Major inflow come from fissure and karstic permeability zones in the depth 2100 – 2600 m. The wells parameters got from the well tests were better than originally expected from the previous oil and gas exploration - geothermal water temperature at wellhead 124 - 129°C , free flow 56 – 65 kg/s, dynamic pressure on wellhead 0,97 – 2,2 MPa (Tab.1), degassing point in depth 750 m - 1195 m, hydraulic parameters: T range from $8,16 \cdot 10^{-5}$ m^2/s to $3,41 \cdot 10^{-4}$ m^2/s and k_f range from $9,44 \cdot 10^{-8}$ m/s to $8,50 \cdot 10^{-6}$ m/s (Fendek, 1998, Giese 1998, 1999, Jetel 1999). Geothermal water has high TDS content (29 - 32 g/l) with remarkable natrium-chloride type. High TDS content in the geothermal water restrain its discharge into adjacent brooks or rivers. From genetic point of view it is halogenic water originated probably from meteoric water infiltrating through the salt-bearing formation of Karpatian into Mesozoic collector (Bodis et al. 1998, 1999). The geothermal structure according to chemical and isotopic indications is the confined one therefore can be used just with the reinjection system. On the basis of thermodynamic modelling great possibility of scaling (plausible phases are predominantly carbonates) as well as of high corrosion, which implies the necessity of inhibitor dosage and other precautions. Model calculations were proved also by measurements in situ. To prevent the precipitation of calcite and other mineral phases the CO_2 partial pressure should be kept at 2.1-2.2 MPa, i.e. the utilisation under pressure is inevitable (Drozd and Vika, 1998). The existence of three geothermal wells provides the possibility of one geothermal heat exchange centre construction.
At present the 3D seismic measurements are performed to progress in new geothermal centres location.

2.3.2. Heat utilisation

The heat from well sites will be delivered to TEKO Kosice by pipeline from heat centre in Olsovany. The heat exchange centres are planned to be built in Bidovce, Durkov, Slanec and Ruskov. From TEKO Kosice by network already built in the town the heat from geothermal wells will be supplied to the dwellings of the town Kosice.
In the Feasibility study done by CFG Orleans, France, Virkir Reykjavik, Iceland and Slovgeoterm Bratislava, Slovakia evaluation of geothermal energy utilisation is elaborated. The study takes into account that in this town exist an extensive heating network that provides heating for 60 000 flats, shopping centres, community service buildings and the others. This district heating service called TEKO (Tepelna energetika Kosice) belongs to Slovak Electricity (SE). About 70% of the heat energy of the TEKO district heating come from natural gas and 30% from coal. Total heat capacity of the heating system is 700 MW with annual heat production 2500 GWh (Bjornsson and Tournaye,1999). The geothermal energy source from Kosice basin is well suited for utilisation in central heating of Kosice town. Geothermal energy is here economical option for replacement of the outdated equipment of TEKO plant. According to the well test results the wellhead temperature on Durkov geothermal centre should be about 125°C, the flowrate 60 – 65 kg/s and reinjection temperature max 55-60°C, so one well is capable to deliver heat output of 16 MW.

2.3.3. Exploitable geothermal energy

In order to examine the energy conversion possibilities for a system it was constructed the so-called energy duration diagram (Fig. 3). This diagram exhibits the power or heat demand throughout the year as a function of the ambient temperature. The area under the curves represents the respective annual energy requirement. In the case of the total demand curve of the heating system, the area indicates the total annual energy demand, and in the case of the geothermal heating curve the area indicates the energy replaceable by geothermal heat. The diagram depicts available heat from geothermal water depending on number of wells and average output from each well. The geothermal curves in Figure 3 are drawn on the assumption that the average temperature of the geothermal water at the wellhead heat exchanger is T_{geo}= 125°C and the flowrate from each well Q_{well} = 65 l/s (or 61 kg/s). The results show that in order to meet a "100 MW" criterion throughout the year 7 wells will be required, although 6 wells will be sufficient for part of the year. If the temperature and flow rate turn out to be lower on average, 7 wells will be required (Table 2). It is therefore concluded that at least 7 production wells must be drilled to ensure the required output from the geothermal field. It is recommended that the full capacity of the 7 wells be utilised during the heating season, to ensure optimum economy of the investment. Figure 4 shows that the energy replaced by the first two wells lies between 210 000 and 250 000 MWh/year based on the 1998 demand, and is reduced rather rapidly to about 150 000 MWh/year for the 5th and 6th well. With 6 doublets exploited to their full capacity the geothermal operation will ensure about 45% of the annual heat demand of TEKO, and with 10 doublets 65% (Figure 5), based on the 1998 demand (Bjornsson and Tournaye, 1999). Similarly, 7 doublets could cover about 50% of the annual energy demand.

4.. CONCLUSIONS

Wide geothermal energy utilisation represent the contribution to energetic and ecological situation therefore its utilisation is supported.

The project in Podhajska is focussed on greenhouses heating in area of 2 ha with the heat output 12 MW_t. The geothermal water (temperature 82°C) from the well Po-1 (TDS 19 g/l) is after heat exchanger reinjected back to reservoir by well GRP-1 (45°C). This system ensures the ecological utilisation of geothermal source.

Galanta town is situated in the southern part of Slovakia. The energetic potential of 8 MWt is supplied from 2 geothermal wells FGG-2 and FGG-3. In 1996 the geothermal station operated by Galantaterm ltd. with financial support of Slovak gas industry, Galanta town, Slovgeoterm, NEFCO Helsinki and Hitaveita Reykjavik was constructed. The geothermal energy provide heating of 1236 flats in "Sever" quarter, complex of Regional Hospital buildings and House for retired people. Both the delivery of district heat and hot water supply are ensured by geothermal.

The investigation in Kosice geothermal structure confirmed the existence of geothermal reservoir and provide the good possibility for one geothermal centre construction. The pilot wells GTD-1,2,3 showed good parameters of the geothermal water (wellhead temperature 124 - 129°C), but the geothermal structure according to chemical and isotopic indications is the confined one and therefore can be used just with the reinjection system. On the basis of thermodynamic modelling great possibility of scaling (plausible phases are predominantly carbonates) as well as of high corrosion, which implies the necessity of inhibitor dosage and other precautions. Kosice town is the second biggest town of Slovakia with installed central heating network. The heat will be delivered by secondary loop from heat exchange centres into TEKO (heat network operator). The close presence of consumers makes the project effective and profitable. The realisation of the whole project with about 7 production and 7 reinjection wells with total heat output 100 MW would follow up.

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Table 1:Well data in dynamic conditions

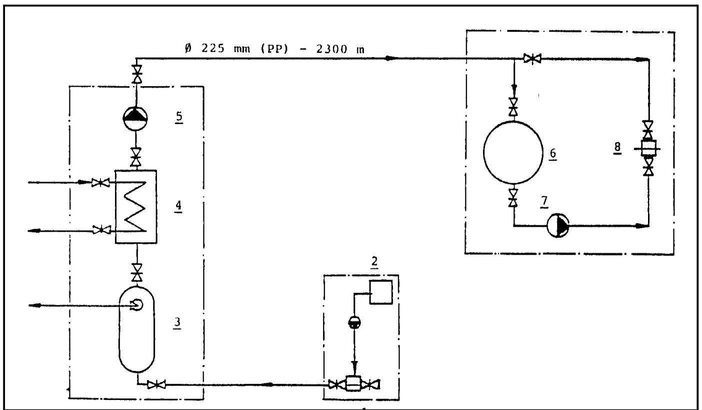
WELL	T (m^2/s)	K_f (m/s)	Inflow (m)	Degassing point
GTD-1	2,089 * 10^{-4}	4,471 * 10^{-7}	2150 – 2500	750 m
GTD-2	8,16 * 10^{-5}	9,44 * 10^{-8}	2750 – 2920	1070 m
GTD-3	3,41 * 10^{-4}	8,50 * 10^{-6}	2223 - 2246	1146 m

Table 2: Power and annual energy delivered by "high" average output from geothermal wells.

"High" output T_{geo}=125°C and Q_{well}=65 l/s, dt_{hx}=4°C	**6 wells**	**7 wells**	**8 wells**
100 MW limit	~ constant	< -15°C	< -15°C
Minimum output during winter	84 MW	98 MW	112 MW
At temperature	-15°C	-15°C	-15°C
Maximum heat output	105 MW	123 MW	141 MW
At temperature	3°C	3°C	3°C
Energy replaceable by geothermal acc. to 1998 demand	641 GWh	719 GWh	795 GWh

Figure. 1. Geothermal sites location

Figure. 2. Reinjection system Podhajska



1-production well Po-1	5-transmission pump
2-inhibitor injection	6-water tank 38 m^3
3-degaser	7-high pressure pump
4-heat exchanger	8-reinjection well GRP-1

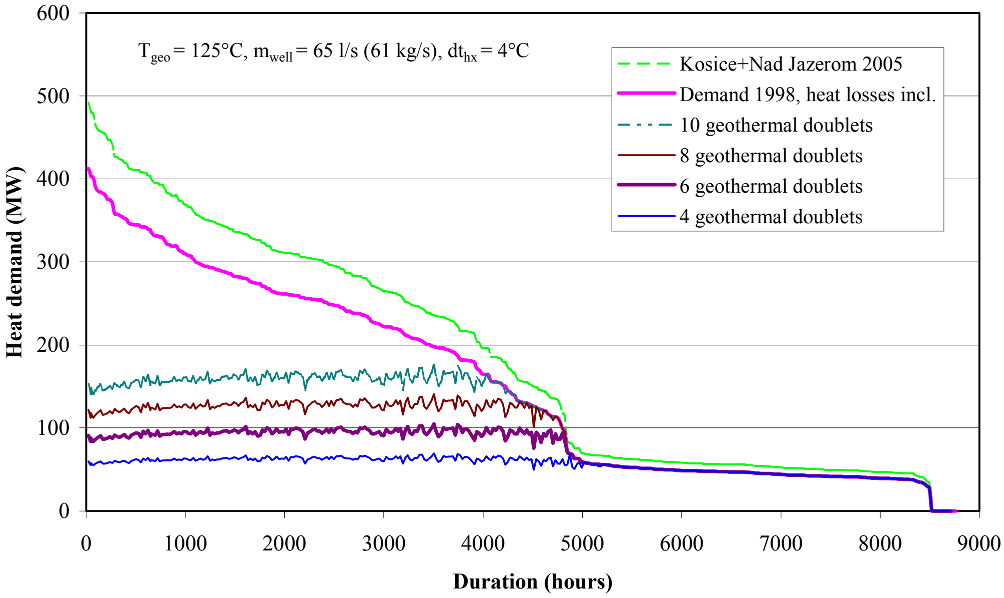


Figure 3: Energy duration diagram - replaceable energy by geothermal

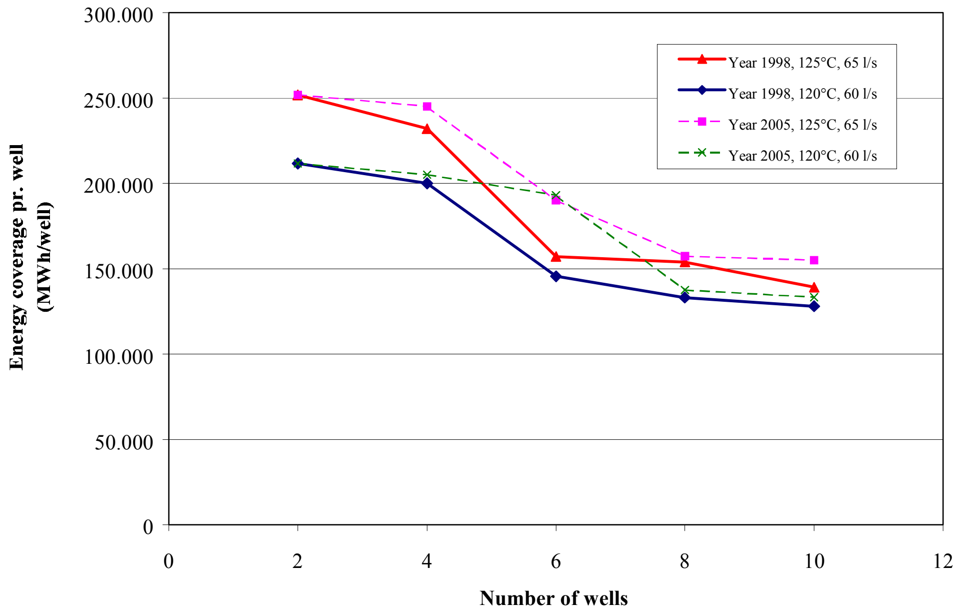


Figure 4: Replaceable energy by geothermal. Applies to the heat demand of the years 1998 and 2005.

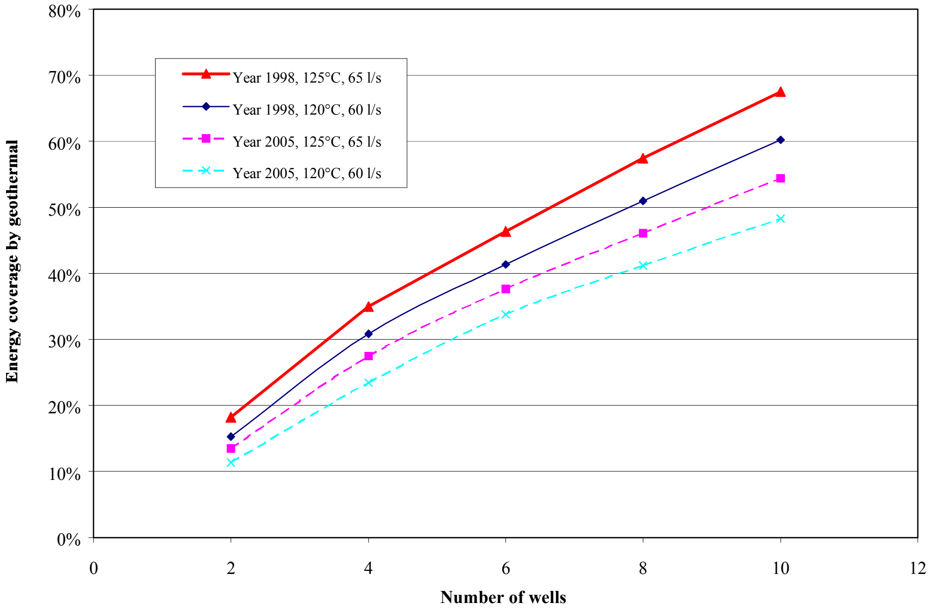


Figure 5: Percent heat energy replaceable by geothermal. 6 wells will ensure about 45% of the energy acc. to 1998 demand.