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Development of geothermal energy utilization in Slovakia

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ABSTRACT

Since year 1991 in the territory of Slovakia totally was utilized the geothermal energy of **83** MW_t, but with very low efficiency **(30** %), so the real power was about 25 MW_t. From year 1991 the important changes started in geothermal energy utilization. The government of Slovak Republic released the finance to solve technical problems like reinjection, scaling, improvement of efficiency etc. The geothermal energy utilization was involved to the energetically conception of Slovak Republic. The cooperation with foreign experts and companies bad begun very quickly. Based on this cooperation first feasibility studies and realization projects were created. The first geothermal project, the construction of reinjection station in Podhájska locality, was finished in the year 1994. In the 1996 the frst geothermal beating plant, with capacity of 8 MWt, in the Galanta town started working. In the 1998 the first three wells from the considered 10 doublets were drilled in the KoSice basin. **An** installation of 110 MW, source that would be used as a thermal power station for central supply of heat for KoSice town with overall capacity of 700 MW is considered. In January 1999 frst of 4 wells start to be drilled in the town Ziar nad Hronom. The 30 MW_t geothermal heating plant will supply the heat for 27 000 habitants for this town. The realization feasibility studies are prepared for several localities in territory of Slovakia (Oravice, Poprad Liptov basin etc.). Up to 1995 an amount of 74,7 MW, had been practically utilized, that means the amount of 1217,7 TJ/year of energy **use,** but conditions for utilization of 180 MW, before year 2000 are being created.

KEYWORDS

Hydrogeothermalcondition, energy conception, studies, projects, realization

1. Introduction

Energetic conception of Slovak Republic included to the renewable energetic sources the utilization of forest biomes, small water power plants and geothermal energy, solar and winds energy, biogas from the wastes, municipal and industrial waste and also the waste

heat. Energetic potential of these sources represents about 4 % of the primary energetic sources utilizable in the year 2005 respectively 2010 that means 40 000 TJ/year. From the mentioned sources on the first places is utilization of biomes (29 %) and geothermal energy (18 %).

Geothermal water and possible hot dry rock utilization represents in the frame of Slovakia the alternative source of energy. In the case of lack of energetic sources, increase of prices, environmental protection mainly air, the geothermal energy can be effectively used in the regions and localities as the local available source of heat, and in the case of favorable conditions, also the electric energy. Generally was declared that one of the partial solutions that can substitute the fossil fuels, is the geothermal energy utilization. The Slovak Republic belongs to the countries where total installed power is around 100 MW_t. Up today results and assumed possibilities create the real conditions for the feasible geothermal energy utilization in the territory of Slovakia.

2. Hydrogeothermal conditions

Results of the geological research and investigations ranks the territory Slovakia to the over average regions. According to the Muffler, **L.P.J.** (1976, FRANKO et al. 1994) classification, the territory of central part of the Inner West Carpathians together with Slovak Ore Mts, „klippen belt" zone in the West and middle Slovakia and West part **of** the Outer West Carpathians belongs to the areas with the normal (average) heat flow density and geothermic gradient. North part of Panonian basin (Danubian, South Slovakian and East Slovakian basins middle Slovakian neovolcanics) belongs to the areas associated with the Recent volcanism. Geothermal activity in this area is higher than normal. According to the mean value of heat flow density ($q = 82\ mW/m^2$) the geothermal activity in the territory of Slovakia is quite higher. Similar the mean value of geothermic gradient is higher than world average (ca 38 °C/km). Temperature at the depth 1000 m is in the range from 20 °C in the Komárno high block to the more than **70 "C** in the **South** Slovakian and East Slovakian basin.

Based on the amount of result from research and investigation, 26 potential geothermal areas were delimited on the territory of Slovakia. During the years 1971 – 1991, 61 geothermal wells were realized in the 14 areas. 5 geothermal wells were realized during the years 1991 – 1998. Together with 58 wells were verified ca 280 MW_t what represents ca 11901/s of geothermal waters with temperature in range 20 – 126 °C (reference temperature 15 "C). For the verification by wells still remain for the renewable utilizable amount of geothermal energy ca 390,5 *MW*, and for non renewable ca 4868.2 MW_t, that means together 5258.7 MW_t. Totally energy potential of geothermal waters in the delimited areas (verified, probable and predicted) represents ca 5538.0 MW, (Tab. 1).

Table 1: Heat – energy potential of geothermal waters in Slovakia

UTILIZABLE AMOUNT OF GEOTHERMAL ENERGY (MW_t)					
Renewable			*Non renewable*[1]		
Probable	Verified	predicted	Probable	verified	Predicted
321.0	162.5	69.5	4511.0	116.2	357.8

[1] Cold front from reinjection to exploitation well will come over 40 years

3. Strategy and development of geothermal energy utilization in Slovakia

3.1 Government support

Against to the geological research and investigation works the effectiveness and technological level of geothermal energy utilization was very low. The reason was the seasonal utilization and low efficiency of geothermal stations. Waters from geothermal wells were used in the 13 agricultural farms (greenhouse heating, soil beating), in 4 localities for heating of service buildings, in one locality for sport hall heating, in 2 localities for fish farming, in 1 locality for restaurant heating and on 15 localities for recreational purposes. Totally the geothermal energy was utilized in 35 localities from sources with power of 83 *MW*,, but with very low efficiency (ca 30 %). The information about utilizable amount of geothermal energy, from the years 1971 – 1994) is presented in the **„Atlas** of geothermal energy of Slovakia" (FRANKO et al. eds. 1995).

The qualitative changes in the geothermal energy utilization in Slovakia started in year 1991. The geothermal energy utilization was involved to the energetic conception of Slovak Republic. The Government resolution, from the year 1993, orientated the geothermal energy utilization to the most perspective areas **as** KoSice basin, Poprad basin, Liptov basin, Central depression of Panonian basin, with the possibility of expected installed power of 335 MW_t and the conditions for utilization of 180 MW_t before 2000 year have been created. From the government, in the frame of research and technical development, were released finance sources for the technical project in which were solved the problems as water chemistry, corrosion, scaling, heating and exchange systems, reinjection etc. Due to fact, that was necessary to increase the efficiency of geothermal energy utilization, the Ministry of Economy finances the project „Utilization of renewable and secondary sources of energy" which include the project "Utilization of geothermal energy" and from the year 1995 the project „Intensification of utilization of renewable and secondary sources of energy". In frame of these project were worked out the pre-feasibility studies and completely analyzed the possibilities of geothermal energy utilization on the most important localities and areas (ca **20** localities) e.g. Poprad, Oravice, KoSice (**FRANKO** et al. 1996a, b, c), Bojnice (VÁNA et al. 1996), Liptovský Tmovec, Bešenová, Oravice, Vysoké Tatry (**FRANKO** et al. 1997a, b, c, d), KoSice basin (VÁNA et al. 1997).

During the years 1993 – 1995 Ministry of Environment financed the study ,,Inventory of the geothermal sources and its possible utilization in the Slovakia" (FRANKO et al. 1995). In frame of this study also was worked out several pre-feasibility studies.

In the year 1996 Ministry of Environment together with Ministry of Economy SR worked out the ,,Conception proposal of geothermal energy utilization in Slovak Republic" to which the Slovak Government accept the ,,Resolution". In this resolution government obliged Minister of Environment to secure the evaluation of geothermal resources and geothermal energy of Central Depression of Panonian basin - locality Galanta, Poprad basin, Liptov basin and Skorušiná depression and to the end of 1998 to prepare the hydrogeothermal evaluation of Ziar basin with the proposal for the realization of the first well to the end of year 2000 and to worked out the study of possibilities for implementation the ,,hot dry rock" project on the territory of Slovakia.

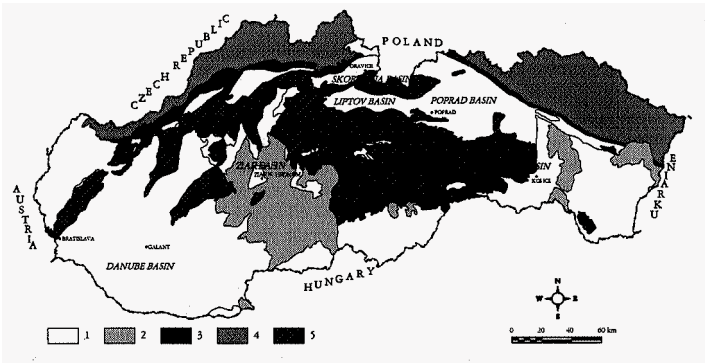

Figure 1: Perspective geothermal areas (1- Neogene and Paleogene basin; 2- Neovolcanics; 3- Klippen Belt: 4- Flysch Belt: 5- Core Mountains, Mesozoic and Paleozoic)

3.2 International cooperation

Together with the support from the state and with the increasing efficiency of geothermal energy utilization the international cooperation started with the countries in which the geothermal energy utilization has the long tradition and high level.

Iceland: cooperation started in the 1990 when was signed the agreement between Slovak and Iceland governments, which included the geothermal energy utilization. Based on this agreement the share holding company Slovgeoterm a.s. was established in the 1992 and following feasibility studies of geothermal energy utilization on the locality Podhájska and

in the town Galanta were worked out. Due to this cooperation first geothermal energy heating station was realized in the town Galanta.

France: based on the results agreed on the discussions between Ministry of Environment SR and France the ,,Project of research - technical cooperation in the field of geothermal energy with French companies in the Slovak Republic'' was worked out. Consecutive its realization and financing by French Government, EC Phare and Ministry of Environment of SR was approved. In frame of this cooperation the preparation of 100 MW, geothermal project in KoSice town started to be realized. As the professional partner from France was named CFG Orleáns. This company also helped with processing the pre-feasibility studies in Vysoké Tatry (High Tatras) region.

Austria: by the cooperation between Slovgeoterm a.s. and Austrian Co. Allplan Wien the pre-feasibility study for the geothermal energy utilization in the town Liptovský Mikuláš was prepared.

Israel: it was started the cooperation with the company ORMAT according to use the geothermal energy for electricity production in the KoSice project

Denmark: Danish Environmental Agency and company Houe & Olsen cooperate on the project of geothermal energy utilization in the town Ziar nad Hronom and in the Orava region.

Poland: company Geotermia Podhalanska is cooperating on the geothermal project in the town Ziar nad Hronom and also is cooperating with other Polish companies around the long-term period geothermal water utilization in the both sides of Vysoké Tatry (High Tatras).

3.3 Financing

The main problem in the geothermal energy utilization is the financing of the projects. In today Slovakia is not possible, according to high interest rate, take the loans from the Slovak finance institutions. Only way is to take the grants and soft loans from the foreign financial institutions mainly from the funds which do not need the state guarantee. But any way they gave loan easier when one of the shareholders (from the company that is going to utilize geothermal energy) is the strong local (Slovak) company and following, the banks are asking for guarantee from this company. The another great problem is the financing of the fust investigation geothermal well. In the most areas in which occur the medium or high temperature geothermal waters available for energy purposes where not realized geothermal wells, in some were realized the oil wells not suitable for such a business. The state is not able to take a geological risk for the first well anyway where the reservoir was find with oil or gas wells. The state obvious can financed only the small part (e. g. hydrodynamic test) of the well costs. And the situation is more complicated than to take loan for the whole project, because also foreign finance institutions do not like to finance the risk of the first well, and if they can then only a part of investment. Only form up today how to help with financing of the first well is to use own capital with foreign founds like EC PHARE, State Environmental Founds. Bank Environmental founds and initiatives etc.

So the financing of the geothermal wells and projects is as follows. Up to year 1990 everything was financed by state. From the year 1990 the state (Ministry of Environment, Ministry of Economy) and EGU (Energetic Research Institute) gave the money for research, pre-feasibility studies, partly for the feasibility studies and small amount for the first geothermal wells. EC PHARE ENERGY gave the grant for the first two wells in the KoSice basin and co - finance the feasibility study for the KoSice geothermal project. SPP š. p. (Slovak Gas Industry) gave the money for the research projects (reinjection etc.), co – finance the feasibility studies (Galanta, Podhájska KoSice), co-finance the wells in KoSice basin. ZSNP a. s. (Aluminium plant in Ziar nad Hronom) co-finance the geothermal project (included the first well) in the town Ziar nad Hronom. Nord Investment Banks gave the loan for realization of the geothermal project in town Galanta. The financing of Ziar geothermal project is discussed and planned with EBRD. For the KoSice project the financing is assumed with several finance institutions.

Several foreign professional institutions from Iceland, France, Poland, Denmark, Austria helped on the developing of geothermal energy utilization, cooperated on the geothermal projects as well as helped with establishing of the several professional Slovak geothermal institutions were Slovgeoterm a.s., Galantaterm s. r. o., ZSNP Geothermal s. r .o. etc.

3.4 Present state and perspectives of geothermal energy utilization development

At 15 localities geothermal waters are utilized for recreational purposes, at 14 localities in agriculture and at 6 localities for space heating. The total installed heat power is ca 100 MW,. At many localities are very good conditions (based on the results of feasibility studies) for geothermal energy utilization, mainly for heating. The projects before realization are e.g. at locality Nováky, Bojnice, in temtory of High Tatras etc.

The most interesting projects that were realized, are under construction and will be realized in the near future are presented below.

GEOTHERMAL ENERGY UTILIZATION IN THE TOWN GALANTA

The Galanta location is a part of the central depression. Two geothermal wells, FGG-2 and FGG-3, were drilled during 1993 and 1994 in this site. Both wells exhibited production flow rate 25 $l.s^{-1}$ with geothermal water temperature of 78°C and with relatively low salinity ranging from 4,3 to 5,9 $g.l^{-1}$. On the basis of these wells a geothermal heat plant with power capacity of 8 MW was built in 1996 (BENOVSKÝ et al. 1997). This plant supplies housing quarters SEVER with 1236 flats in 77/56°C system, together with a district hospital in radiator system 90/70°C and floor heating system 52/42°C, and delivers domestic hot water for the housing quarters and hospital.

Total investment for the construction was cca 3,5 mil. USD. Main part was financed by the loan from NIB (Nord Investment Bank). The shareholders of company are town municipality Galanta, SPP š.p., Slovgeoterm a.s., Hitaveita Reykjavik and NEFCO Helsinki. After 2 years of productions it looks that cash – flow which was worked out on Iceland was more pessimistic and pay back period will he shorter, below 7 years.

According to the construction of geothermal Energocenter in Galanta was closed the boiler station in town hospital (coal based). Boiler station yearly consumes 6200 t of coal and produced 330 t SO_2, 36 t NO_x, 159 t CO_2, 600 t breeze. The charges according to pollution was 156000 Sk. The consumption of gas in the boiler station on the habitation „Sever" was decreased from 3 mil Nm^3 to 1,2 mil. Nm^3 of gas, what decreased the emissions of 60 % against former state situation.

PROJECT OF GEOTHERMAL ENERGY UTILIZATION IN THE KOŠICE BASIN

The object of project is the utilization of geothermal heat in the amount of 100 - 110 MW, for heating of the town KoSice. The source of geothermal water with temperature 115 – 150°C from the depth interval 2100 - 3200 m was indicated by the oil and gas investigation. The power 100 - 110 MW_t of hot water with temperature 115 - 120 °C with cooling to 65 °C is useful to consumer, which is heating station KoSice (TEKO), where the heat demand is 300 - 700 MW with year supply of heat 6700 TJ. The project investment represents ca 1700 mil Sk with payback period 4 - 6 years with high environmental effect according to comparison with coal and gas burning. The perspective of geothermal heat utilization in this territory represents the useful heat power in the range up to 300 *MW*, with year utilization of 5000 TJ.

In the present time fust three wells were realized in the KoSice basin. They verified and confirm the assumption of geothermal sources in the carbonate reservoir in the KoSice basin. Results of fust wells are in the table below.

Table 2: Results from the wells in Košice basin

Well Name	Depth (m)	Free flow (l/s)	Wellhead temp. (°C)	T.D.S. (g/l)
GTD-1 (vertical)	3200	65.0	124.0	28.0
GTD-2 (deviated)	3150[1]	65.0	125.0	29.0
GTD-3 (deviated)	2200[1]	80.0	126.0	27.0

[1] vertical depth

For this project the detail realization study was prepared (VÁNA 1997; CUNDERLÍK et al. 1996). For the town KoSice and its vicinity was from the year 1967 gradually built the central heating system (SCZT) with total power 700 MW_t. This source is connected with heat distribution system with satellites heat exchange stations, which supplied by heat 60 000 households in KoSice and its vicinity. Partly with heat are supplied the industry objects. The source have the install power on output 560 MW_t in the hot water part and in the steam part 120 MW_t. The year heat supply represents 6700 TJ. The present state analysis shows, that the steam and generator part of TEKO - 1 are on the lifetime border and after their disposal is necessary to replace the heat and electrical power in the range 140 - 150 MW, and 55 MW_e. The important problem is several overstepping of emission

limits according to old system of coal and gas burning, replacing the old sources with geothermal beat looks like a rational alternative. By the realization of 8 doublets, which represent the power 110 MW_t and year heat production 2500 TJ, is possible to cover more than 1/3 of total beat production in **TEKO** station.

Economical evaluation **of** geothermal source utilization was worked out on the basis of preliminary calculations of investment and operating costs and assumption of loan holidays during first 5 years of operation and for following input data (short version):

• **start of construction**		01/2000
• **Start of operation**		06/2003
• **Time of construction**		36 month
• **Economical lifetime of construction**		*20* years
• **Financing of construction**	part of own capital	**30 %**
	endowment	10 %
	part of other capital (loan)	60 %
TOTAL EXPENSES FOR CONSTRUCTION		**58 mln. EUR**
PAY BACK PERIOD		**4 – 5 years**

By the realization of this project will be verify the energy source, which has according to hydrogeothermal assumption the heat power **of** 300 MW_t. This project after realization will become the greatest geothermal project in Central and Eastern Europe.

PROJECT OF GEOTHERMAL ENERGY **UTILIZATION** IN THE TOWN ZIAR NAD HRONOM

In the area **of** the town Ziar nad Hronom **(27** 000 inhabitants) are very good geothermal conditions. At the depth 2500 m it is possible to find the geothermal waters in the Triassic dolomites and liiestones with temperature around 100 °C.

Heat demands of Ziar nad Hronom covers 2 individual systems of central heating, one is supplied with hot water from ZSNP (Aluminum plant) boiler station and the second system is based on delivery of the gas. The boiler station in the *ZSNP* a. **s.** burns the black coal and the emissions **of** contaminates are so high, that they do not fit the standard of new environmental legacy. These limits must to be fulfilled to the end of 1999.

Together with the Danish company Houe & Olsen was worked out the feasibility study of geothermal energy utilization for heating of town and ZSNP **a.s. In** the feasibility study were solved several variants which evaluated different condition which will occur after implementation **of** geothermal energy heating in Ziar region.

Heat production based on the geothermal energy according to most effective geothermal variant is in the following table.

Table 3: Heat production

Year heat demand	803.4 TJ/year
Geothermal wells production	692,1 TJ/year
Electricity consumption	8760.0 MWh/year
Heat production from boiler station *(ZSNP)*	111,3 TJ/year
Coal consumption	9569,0 t/year
Electricity consumption	53,0 MWh/year

This Variant will cover 73 % of actual heat demand (949 TJ/year. The realization of this variant will last 3 – 4 years. The total investment was assumed to **18 318** 300 **USD.**

The environmental asset according to reduction of pollution was calculated on the base of CO_2, CO, SO_2, NO, according to coal burning. Year environmental asset represent **3** 099 **000 USD.** The basic economical and financial evaluation is shown in the table 4.

Table 4: Economical and financial evaluation – basic version (thousand USD, 1998–2012)

Investment	18 318
Economical income	114 984
NPV, finance (12 %)	2 598
NPV, economic (12%)	20 514
FRR	15,31 %
ERR	36,26 %

The drilling of the fust geothermal well (2500 m deep) in the town Ziar and Hronom started in January 1999.

4. Conclusion

The geothermal energy utilization qualitatively and quantitatively changed during past ten years. This changes was possible to made due to fact that on the one side started the intensive international cooperation (educational, technical, economical) together with establishing of new professional companies and on the other side the interest from the Government of Slovak Republic, mainly the including the geothermal energy to the energetic conception of Slovak Republic. Also the plumbless fact is the interest from foreign finance institutions to finance environmental projects.

Above are described only few geothermal projects. The geothermal activities on the territory of Slovakia are much higher e.g. is prepared 25 MW, geothermal heating project in the West Tatras – Orava region. Many owners of geothermal wells had a great interest of utilization of this source of energy (mainly in recreational facilities). But the problem is still financing. From my opinion if Slovak financial institutions will give the good loan

conditions, than also this activities will be fulfilled and the consequently the rapid development of tourism will start.

Based on the above mentioned, we can confirm that geothermal energy utilization in our condition is perspective, economical effective also according to high starting investment. After realization **of** KoSice and Ziar nad Hronom projects the Slovakia can he involved into the forward countries in the geothermal energy utilization. Also the influence on the improvement of the environment is very high, because Slovakia is still country with high pollution. ***So*** only way is to continue with the trend, that we started 10 years ago.

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