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Geothermal energy utilization in Slovak Republic

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Abstract: In the territory of Slovak Republic 132 sources (wells, springs, etc.) with water temperature in the range 15.7 – 125.0 °C are registered until now. The depth of geothermal wells ranges from 40.0 up to 3500 m. Thermal capacity of these geothermal waters amounts to some 269.95 MW_t which is equivalent to 1672.0 l/s. That is the reason why the geothermal energy utilization was involved into the energetic conception of Slovak Republic. The first geothermal project, the construction of reinjection plant in Podhájska, was finished in 1994. In 1996 the first geothermal heating generating plant with capacity of 8 MW_t in Galanta started to work. The realization feasibility studies are prepared for several localities in territory of Slovak Republic (Košice, Poprad, Liptov, Skorušina and Žiar basins, etc.).

Key words: geothermal water, geothermal wells, thermal capacity, geothermal energy utilization, space heating, green houses, swimming pools

Introduction

Renewable energetic sources like utilization of forest biomass, small water and geothermal energy power plants, solar and wind energy and biogas were included into the State Energetic Conception of Slovak Republic. 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 the utilization of biomass (29 %) and geothermal energy (18 %) are the most important.

Geothermal energy can be effectively used in the regions and localities as a local available source of heat in the case of lack of other energetic sources or increase of fossil fuels prices. In the case of favorable conditions geothermal energy can be also used as a source of the electric energy generation. According to sustainable resources management and environmental protection sources of geothermal energy were declared for one of the partial solutions which can substitute the fossil fuels.

Low enthalpy ($15 < t < 100$ °C), medium enthalpy ($100 < t < 150$ °C) and high enthalpy ($t > 150$ °C) geothermal resources occur in territory of Slovak Republic. The most frequent of them are low enthalpy and the least are high enthalpy geothermal resources. Slovak Republic belongs to the countries where total geothermal energy installation is over 100 MW_t. Obtained results and assumed possibilities create the real conditions for the feasible geothermal energy utilization in the territory of Slovak Republic.

Utilization of geothermal energy

Historical background

The old history of utilization of geothermal energy in Slovak Republic is mainly the history of utilization of thermal springs. Thermal balneology established itself as a local tradition since prehistoric time. From times immemorial attention was paid to mineral and geothermal waters, not only by common people but also by travelers, foreign visitors and scientists. Great richness of these waters on the Western Carpathians territory is reflected in characteristic geographical names of villages, towns and springs already since the arrival of our predecessors at this area. These names have been living up to these days even on places where such waters are not to be found at present. The era of Humanism gave cause for more precise investigation of these waters, their qualities, singularities as well as possibilities of their technical and curative utilization. Many archaeological finds discovered at the site and in the surroundings of thermal springs indicate that man was attracted to settle in these friendly areas. In historical times, the use of these waters and the associated thermomineral mud became progressively more frequent and systematic, so that many thermal localities acquired a significant importance as recreational and curing stations.

Thermal springs were known as early as in the Middle Ages, in the 15th, and particularly in the 16th centuries. It was Georg Wernher, a humanist scholar, who brought them to the attention of the public in his work *De admirandis Hungariae aquis hypomnemation* (Basilae, 1549). In the 17th century a scientific work appeared, which was the first hydrogeological study in this region. It was the 8th dissertation of Martin Szentiványi's *"Miscellaneas "* (1689). The 18th century witnessed an explosion of interests in mineral and thermal waters. Not only scientists but also political leaders tried to apply in economy and medicine what had been exploited abroad with advantage in the previous period. In the first half of the 18th century Matej Bel together with his informants, assembled the known facts about mineral and thermal springs and their

practical application. He did not only illustrated contemporary knowledge of them but often spoke of their history, of his own experiences with springs of mineral and thermal waters in Slovakia and of their utilization. Thanks to M. Bel and his informants 137 places with mineral and thermal waters got a lot of publicity (Rebro, 1983).

One of the first balneographies was the work of H. J. N. Crantz (1777), Professor of Viennese University. It records 158 places with mineral and thermal springs in Western Carpathians. He analysed many of those waters later himself. Most admired were naturally the well-known spas: Piešťany, Trenčianske Teplice, Rajecké Teplice, Turčianske Teplice, Sklené Teplice, Vyhne, Sliač, but also Svätý Jur, Pezinok, Lipovce, Rudno, etc.

Pavel Kitaibel emerged towards the end of the 18th and at the beginning of the 19th centuries. His work *"Hydrographica Hungariae"* (1829) surprised with its depth of knowledge of many significant localities from the perspective of the analysis but also with its botanical approach and attitude, particularly in his monographs about mineral and geothermal waters and spas in Slatina, Turčianske Teplice and Bardejov.

Although several balneographies appeared in the middle of the 19th century worked up mostly by physicians, it was David Wachtl's work *"Ungarns Kurorte und Mineralquellen"* - Hungarian Spas and Mineral Springs (1859) that was the most significant and most the instructive.

The well in Gánovce drilled to the depth of 183 m in the year 1879 is regarded as a first geothermal well drilled in the territory of Slovak Republic. The value of free outflow from the well was 13.5 l/s of geothermal water with temperature of 24 °C. The second one geothermal well followed in 1899 in Kováčová. The value of free outflow from the depth of 473 m was 12.5 l/s with temperature of 40.5 °C.

First utilization of geothermal waters for energetic purposes is connected with space heating in spas and can be dated to the year 1958. Three systems of direct utilization of geothermal waters were tested (Uhliarik, 1977):

- direct space heating in spas Piešťany, Kováčová, Sklené Teplice,
- utilization of heat pumps in Piešťany and Turčianske Teplice,
- space-heating and heating of hot service water through heat exchangers in Piešťany, Turčianske Teplice and Kováčová.

These first steps created conditions for more extensive research in the field of geothermal energy utilization for direct use in Slovak Republic.

Present state

Based on results of research and investigation in 70-ties and 80-ties, which were carried out by Dionýz Štúr Institute of Geology, 26 potential geothermal areas and structures were defined on the territory of Slovakia. Research, prospecting and exploration of geothermal waters has so far been carried out in 14 prospective areas. In the other 12 prospective areas, geothermal waters have not been verified by wells, but 6 of them have been geologically assessed for the purpose of prospecting and exploration for geothermal waters. The total amount of thermal-energy potential of geothermal waters in prospective areas (proven, prognostic and probable) represents 5538 MW_t and is given on tab. 1 (Franko – Remšík – Fendek Eds., 1995).

Tab. 1: Thermal–energy potential of geothermal waters in Slovak Republic

Resources [MW_t]			Reserves [MW_t]		
proven	prognostic	probable	proven	prognostic	probable
147	85	321	29	445	4511
553			4985		
Total amount: 5 538.0 MW_t					

In spite of the high level of geological research and investigation studies, the effectiveness and technological level of geothermal energy utilization is very low. The first reason is the seasonal utilization, the second one the low efficiency of geothermal installations. Geothermal water is used in 13 agricultural farms (greenhouse heating, soil heating), 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 30 localities for recreational purposes. The total amount of geothermal energy utilized in 36 localities represents thermal power of 130.97 MW_t and 846.4 l/s of geothermal water (tab. 2).

Utilization of heat in agriculture provides great possibilities for early production of vegetables (cucumber, tomatoes, peppers, aubergines, etc.) and flowers. Use of fossil fuels is however too costly and geothermal water can provide an economic answer. The total area covered by greenhouses is about 27.36 ha.

The detailed distribution of geothermal energy sources according to utilizable thermal power of geothermal waters is shown on tab. 3, 4 and Fig. 1

It follows from tab. 3 that the highest amount of utilized sources of geothermal waters is situated in Trnava county which represents 44.47 MW_t. One of them is also Galanta installation. The possibility to obtain geothermal water for the purpose of power utilization in Galanta (central space heating and supply with hot technological water in the Galanta-Sever residential area with 1,100 blocks of flats, a hospital and a rest home) has been verified by the research geothermal borehole FGG-2 Galanta. The Dionýz Štúr Institute of Geology Bratislava realized the borehole in the years 1982 to 1983, in the framework of the research of geothermal power of the central depression of the Danube basin. Based on positive results from this borehole, the survey-exploitational borehole FGG-3 Galanta was realized in 1984 by the Bratislava branch of the IGHP, š.p. Žilina company (Franko et al., 1985). The temperature of the rock environment in the depths of 1,000 and 2,000 m is 51 and 91°C, respectively. Water temperature at the wellhead of the FGG-2 borehole with the free outflow of 27.3 l/s is 80°C and at the wellhead of the FGG-3 borehole with the free outflow of 25.0 l/s it amounts to 77°C.

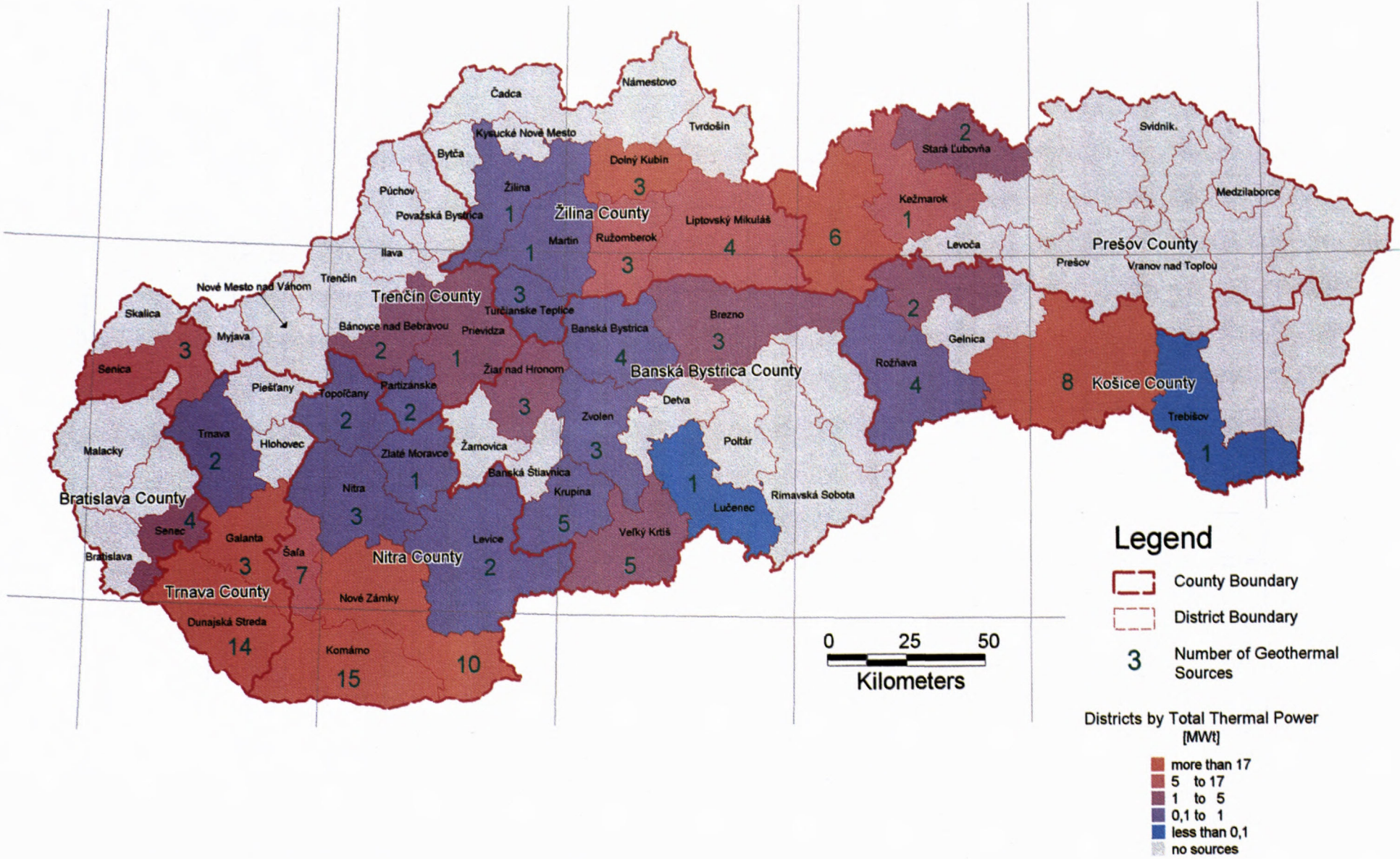

Fig. 1 Distribution of geothermal energy sources in districts of Slovak Republik

Tab. 2: Distribution of utilized geothermal energy sources in counties of Slovak Republic (till 31.12.1998)

County	Number of localities in utilization	Yield [l/s]		Thermal power [MW_t]	
		Total yield	Utilized yield	Total thermal power	Utilized thermal power
Bratislava	0	30.2	0.0	4.42	0.00
Trnava	11	332.2	211.2	72.27	44.47
Nitra	9	469.2	295.7	57.57	40.13
Trenčín	3	30.9	30.2	4.54	4.49
Žilina	5	312.6	184.0	35.25	25.56
Ban. Bystrica	5	131.3	54.2	9.39	5.15
Prešov	2	172.6	70.5	26.87	11.16
Košice	1	195.6	0.6	33.54	0.01
Total amounts	36	1672.0	846.4	269.95	130.97

Tab. 3: Geothermal energy sources with the utilizable thermal power more than 0.85 MW_t

No.	Locality	Well	Well depth m	Year	Yield l/s	Temperature °C	Thermal power MW_t
Bratislava county							
Senec district							
1	Senec	BS-1	1350.6	1981	13.5	47.5	1.84
2	Kráľová pri Senci	FGS-1A	1500.0	1974	14.0	54.0	2.29
		FGS-1	810.0	1974	0.8	23.0	0.03
Trnava county							
Dunajská Streda district							
3	Veľký Meder	Č-1	2250.2	1972	7.0	78.0	1.85
		Č-2	1503.0	1983	16.4	56.5	2.85
4	Čilistov	FGČ-1	2500.0	1979	15.0	52.0	2.32
5	Čiližská Radvaň	ČR-1	2513.0	1986	10.0	65.0	2.09
		VČR-16	1800.5	1989	15.0	64.5	3.09
6	Dunajský Klatov	VDK-1	2500.0	1991	15.0	67.0	3.27
7	Dunajská Streda	DS-1	2500.0	1971	13.0	91.5	4.16
		DS-2	1600.0	1985	23.0	57.0	4.04
8	Eliášovce	VZK-10	1800.0	1987	12.5	65.0	2.62
9	Gabčíkovo	FGGa-1	2582.0	1982	10.0	52.0	1.55
10	Horná Potôň	FGHP-1	2500.0	1978	20.0	68.0	4.44
11	Lehnice	BL-1	1500.0	1985	23.2	54.0	3.78
12	Ňárad	VTP-11	2502.2	1988	15.3	67.0	3.33
13	Topoľníky	FGT-1	2503.0	1975	23.0	74.0	5.68
Galanta district							
14	Galanta	FGG-2	2100.0	1983	27.3	80.0	9.25
		FGG-3	2102.0	1984	25.0	77.0	6.49
15	Sládkovičovo	FGG-1	1900.0	1975	6.5	62.0	1.28
Senica district							
16	Lakšárska N. Ves	RGL-1	2100.0	1984	25.0	78.0	6.59
17	Šaštín-Stráže	RGL-2	2605.0	1983	12.0	73.0	2.91
Nitra county							
Šaľa district							
18	Diakovce	Di-1	3303.0	1962	4.0	38.0	0.39
		Di-2	1551.0	1982	15.0	67.0	3.27
		Di-3	306.0	1983	15.0	19.0	0.25
19	Vlčany	FGV-1	2500.0	1982	10.0	68.0	2.22

Tab. 3– Continuing

No.	Locality	Well	Well depth m	Year	Yield l/s	Temperature °C	Thermal power MW_t
			Komárno district				
20	Komárno	M-2	1060.0	1971	60.0	44.0	7.30
		M-3	742.0	1986	1.0	39.0	0.10
21	Marcelová	GTM-1	1763.5	1988	8.3	56.0	1.42
22	Patince	SB-3	170.0	1982	29.4	26.0	1.35
		SB-2	160.0	1972	15.1	27.0	0.76
		SB-1	226.5	1959199	29.1	26.5	1.40
23	Zemianska Oľča	VZO-14	1849.0	3	10.0	74.0	2.47
24	Zlatná na Ostrove	VZO-13	1650.0	1993	7.0	50.4	1.03
			Nové Zámky district				
25	Bruty	VTB-1	1927.6	1990	10.0	74.0	2.46
25	Dvory n. Žitavou	FGDž-1	2500.0	1980	7.2	62.0	1.42
27	Podhájska	Po-1	1900.0	1973	42.0	81.0	11.60
28	Štúrovo	FGS-1	210.5	1973	35.0	38.0	3.37
		VŠ-1	-	-	35.0	38.0	3.37
29	Tvrdošovce	FGTv-1	2406.0	1978	20.0	70.0	4.6
30	Komjatice	G-1	1830.0	1990	12.0	62.0	2.35
			Trenčín county				
			Bánovce nad Bebravou district				
31	Bánovce n.Bebrav.	BnB-1	2025.0	-	11.0	42.6	1.27
			Prievidza district				
32	Nováky	Š1-NBII	1800.0	1980	15.0	59.4	2.79
			Žilina county				
			Dolný Kubín district				
33	Oravice	OZ-1	600.0	1979	20.0	28.0	1.09
		OZ-2	1601.0	1991	120.0	54.0	19.59
			Ružomberok district				
34	Bešeňová	ZGL-1	1987.0	1986	28.0	61.5	5.44
			Liptovský Mikuláš district				
35	Liptovská Kokava	ZGL-3	2373.0	1990	20.0	43.5	2.38
36	Liptovský Trnovec	ZGL-2	2500.0	1992	40.0	60.7	5.89
37	Liptovský Ján	Rudolf	90.0	1964	22.0	29.2	1.31
			Banská Bystrica county				
			Žiar nad Hronom district				
38	Kremnica	S-1	510.0	1968	23.2	47.0	3.11
39	Vyhne	V-1	92.0	1967	10.0	40.0	1.05
			Zvolen district				
40	Žarnovica	LKC-4	876.0	1980	10.0	35.0	0.84
			Prešov county				
			Poprad district				
41	Vrbov	Vr-1	1742.0	1982	28.3	56.0	4.86
		Vr-2	2502.0	1989	33.2	59.0	6.11
42	Poprad	PP-1	847.0	1994	48.0	48.0	6.60
			Stará Ľubovňa district				
43	Plavnica	Pl-1	3500.0	1986	5.0	65.0	1.20
		Pl-2	3500.0	1988	4.0	53.0	0.57
			Kežmarok district				
44	Stará Lesná	FGP-1	3616.0	1995	40.0	58.0	7.20
			Košice county				
			Košice surroundings district				
45	Ďurkov	GTD-1	3210.0	1998	56.0	125.0	25.77

Tab. 4: Geothermal energy sources with the utilizable thermal power less than 0.85 MW_t

No.	Locality	Well	Well depth m	Year	Yield l/s	Temperature °C	Thermal power MW_t
Bratislava county							
Senec district							
1	Chorvátsky Grob	FGB-1	1231.0	1974	1.9	47.5	0.26
Nitra county							
Komárno district							
2	Komárno	FGK-1	1968.0	1976	4.0	45.0	0.5
3	Nesvady	Kol-3	2835.0	1966	1.5	63.0	0.3
4	Kravany n. D.	FGKr-1	1021.0	1977	5.0	20.0	0.1
5	Svätý Peter	PGT-11	1333.0	1990197	1.1	44.0	0.13
6	Virt	JRD	136.0	3	10.0	26.0	0.46
7	Virt-TK	VŠE	280.0	1976	15.0	24.5	0.6
		HVB-1	241.0	1973	10.0	24.5	0.4
8	Šaľa	HTS-1	902.0	1981	0.8	18.0	0.01
		HTS-2	1200.5	1983	3.5	45.0	0.44
		HTS-3	280.0	1987	2.8	21.0	0.07
Nové Zámky district							
9	Nové Zámky	GNZ-1	1506.0	1983	4.0	51.0	0.6
10	Štúrovo-TK	1949	-	1949	6.0	38.0	0.58
11	Šurany	GŠM-1	1550.0	1990	5.4	49.0	0.77
Nitra district							
12	Poľný Kesov	BPK-1	847.0	1980	3.0	27.0	0.15
		BPK-2	1200.0	1981	4.0	49.0	0.60
13	Pohranice	Jazero	-	-	18.0	15.5	0.04
Zlaté Moravce district							
14	Topoľčianky	KD-1	500.0	1984	3.0	28.2	0.17
Levice district							
15	Pukanec	T.voda	-	-	3.8	18.5	0.06
16	Želiezovce	HGŽ-3	916.0	1990	0.5	72.0	0.12
Topoľčany district							
17	Topoľčany	FGTZ-1	2106.0	1985	2.4	55.0	0.33
18	Továrniky	J-6	400.0	1977	0.3	20.5	0.01
Trnava county							
Trnava district							
19	Koplotovce	KB-2	118.0	1997	-	-	-
		KB-1	118.0	-	18.0	24.0	0.68
Trenčín county							
Bánovce nad Bebravou district							
20	Libichava	J-1	400.0	1977	0.3	30.0	0.02
Partizánske district							
21	Brodzany	HGT-9	160.0	1982	0.4	33.6	0.03
22	Malé Bielice	VB-3	102.0	1983	4.2	39.6	0.43
Žilina county							
Žilina district							
23	Rajec	Rk-22	1308.0	1974	12.0	27.0	0.6
Dolný Kubín district							
24	Párnica	3pram	0	-	32.0	15.7	0.9
Martin district							
25	Socovce	HV-107	160.0	-	12.0	17.0	0.1

Tab. 4 – Continuing

No.	Locality	Well	Well depth m	Year	Yield l/s	Temperature °C	Thermal power MW_t
			Turčianske Teplice district				
26	Diviaky	N-39	320.0	-	0.1	25.7	0.04
27	Mošovce	MZ-2	50.0	1976	10.0	19.0	0.17
		MZ-1	40.5	1976	-	-	-
			Ružomberok district				
28	Liptovské Sliače	VSH-1	250.0	1975	2.0	20.0	0.04
29	Stankovany	STH-1A	67.0	1976	1.6	18.2	0.03
			Liptovský Mikuláš district				
30	Pavčina Lehota	FGL-1	2129.0	1977	0.9	23.0	0.03
			Banská Bystrica county				
			Zvolen district				
31	Zvolen	H-1	40.0	-	2.0	17.9	0.02
32	Borová Hora	Jazero	-	-	0.9	19.0	0.02
			Krupina district				
33	Cerovo	Ck-1	583.0	-	2.0	25.0	0.08
34	Medovarce	GK-3	-	1967	0.7	22.2	0.02
35	Šípice	S-1	83.0	1968	1.0	20.0	0.2
36	Hontianske Nemce	H-1	100.0	1980	2.7	21.0	0.07
		Gk-1	746.8	1965	-	53.5	-
			Banská Bystrica district				
37	Banská Bystrica	SVH-1	117.0	1976	17.0	21.0	0.43
	Štiavničky	BB-1	275.0	1981	10.0	20.0	0.21
38	Badín	-	-	-	0.9	22.0	0.03
39	Vlkanová	VL-1	-	-	0.4	19.0	0.01
			Brezno district				
40	Dolná Lehota	Teplica	-	-	9.0	17.4	0.9
41	Hámor		-	-	2.0	21.0	0.5
		LKŠ-1	180.0	1989	10.0	35.0	0.83
			Veľký Krtíš district				
42	Dolná Strehová	M-4	520.0	1956	2.5	35.5	0.55
		HGDS-1	625.0	1985	6.5	-	-
43	Slovenské Kľačany	TSK-1	600.0	1992	2.0	38.0	0.19
44	Vinica	HVP-1	-	-	3.0	20.5	0.07
		HG-18	-	-	10.0	21.0	0.25
			Žiar nad Hronom district				
45	Voznica	R-3	710.0	-	4.2	27.0	0.21
			Lučenec district				
46	Lučenec	Rakott	-	-	1.3	22.0	0.04
			Prešov county				
			Poprad district				
47	Gánovce	GA-1A	276.0	1975	5.0	21.5	0.14
48	Kišovce	H-74	-	-	0.1	18.4	0.0
49	Hranovnica	Pleso		-	9.0	20.0	0.19
			Košice county				
			Košice district				
50	Košice	G-4	310.0	1982	4.0	26.0	0.18
51	Valaliky	KAH-3	190.0	1974	7.2	21.1	0.18
		KAH-5	160.2	1975	13.2	20.5	0.30
		KAH-9	140.0	1975	11.0	16.7	0.08
52	Trstené pri Hornáde	KAH-2	160.3	1975	0.7	19.5	0.01
		KAH-4	150.0	1975	0.5	19.4	0.01
		KAH-6	163.6	1975	10.0	18.0	0.13

Tab. 4 – Continuing

No.	Locality	Well	Well depth m	Year	Yield l/s	Temperature °C	Thermal power MW_t
Rožňava district							
53	Kunova Teplica	Teplica	-	-	63.3	15.8	0.21
54	Vlachovo	GVL-1	1201.3	1975	0.6	20.0	0.01
55	Rožňava	RS-1	1379.6	1964	3.0	24.0	0.11
56	Meliata	Mel-1		1964	3.0	45.0	0.35
Spišská Nová Ves district							
57	Arnutovce	HKJ-3	1133.5	1992	11.8	31.0	0.79
58	Letanovce	HKJ-4	607.0	1989	8.3	24.4	0.33
Trebišov district							
59	Kr. Liesková	St-21	3738.0	1972	0.3	55.0	0.05

On the base of a complex evaluation of hitherto realized hydrodynamic measurements, it could be enunciated that the demanded regimen of geothermal water exploitation from the FGG-2 and FGG-3 boreholes could not be secured by the free outflow (Fendek, 1995). Therefore, it has been recommended to immerse the submersible pumps in the FGG-2 and FGG-3 geothermal boreholes to the depth of 120 m and 110 m, respectively. In the FGG-2 and FGG-3 boreholes, geothermal water must be exploited by pumping for 70 and 150 days per year, respectively, at the time when the exploitation rates planned for the FGG-2 and FGG-3 boreholes lie within the interval of 6 - 15 l/s and 20 l/s, respectively. This is also the time of the highest mutual influence of those boreholes.

Galantaterm Ltd. – a legal entity has been formed to supply the 1,236 flats of the "Sever" residential area - together with its public service sector and the hospital of Galanta - with heat and hot service water. Geothermal power is used to secure the heat and hot service water. A natural-gas boiler house is used to heat the water when average daily temperature sinks below -2°C. The whole primary system and the secondary circuits of the heat exchanger station are equipped with a control system, which will enable to connect particular boilers gradually to the system in the future, on the box-of-bricks principle: first the peak boiler, then the gas boiler and hospital exchanger stations, and last it is planned to interconnect the points of heat abstraction in flats.

Perspectives of geothermal energy utilization development

Geothermal energy utilization projects prepared and partially realized in Košice, Poprad, Liptov, Skorušina and Žiar basins belong to the most prospective for the near future. The current knowledge of geothermal energy in relation to Slovakia's geological structure was summarized by Geological Survey of Slovak Republic - former Dionýz Štúr Institute of Geology in The Atlas of Geothermal Energy of Slovakia (Franko, Remšík & Fendek Eds., 1995). The results of research studies obtained during more than two decades of investigation are fundamental for scientists, teachers and engineers, for governmental and industrial decision-makers involved in exploring for and exploiting geothermal energy and for the general public interested in this alternative source of energy.

To help the developing of the geothermal energy utilization several professional Slovak institutions were established like Slovgeoterm Inc. Bratislava, Galantaterm Ltd. Galanta, ZSNP Geothermal Ltd Žiar nad Hronom, Geoterm-Košice Ltd. Košice. NAFTA Inc. Gbely can provide drilling of deep geothermal wells. Several foreign professional institutions from Iceland, France, Poland, Denmark, Austria cooperated on the geothermal projects.

The main problem of the geothermal energy utilization is the financing of the project and first verifying geothermal well. Geothermal wells were not realized in the most areas with occurrence of the medium or high temperature geothermal waters available for energetic purposes. In some areas the oil wells, not suitable for such a business, were realized. The State is not able to take a risk for the first well although the reservoir was researched by oil or natural gas wells. In the present, the only form 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.

The prospective part of Košice basin with geothermal waters favourable for electric power production occupies 200 km^2. It is the area around the village Ďurkov. 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. Remšík and Fendek (1992) elaborated first project for pilot geothermal well at the locality. With respect to favorable hydrogeothermal conditions in Košice basin, Dionýz Štúr Institute of Geology informed VSŽ Inc. Košice about the program of exploitation of the geothermal energy for heating and electric power production. Energoprojekt Košice proved the competitiveness of the program. Later, Geoterm-Košice Ltd. Košice was established to implement the project. For this project the detailed realization study was prepared (Váňa, 1997). The object of project is the utilization of geothermal heat in the amount of 100-110 MW_t for heating of the Košice town. The power 100-110 MW_t of hot water with temperature 115 - 120 °C with cooling to

65 °C will be useful for consumer. The perspective of geothermal heat utilization in this territory represents the useful heat power in the range up to 300 MW_t with year utilization of 5000 TJ. The thermal power will be produced by 8 production and 8 reinjection wells. In the present time first three wells were realized in the Košice basin. They verified and confirm the assumption of geothermal waters in carbonate reservoir of the Košice basin. Start of operation is being planned for June 2001. By the realization of the project, energy source will be verified, 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 East Europe.

Projects of geothermal energy utilization in Poprad, Liptov and Skorušina basins have to support traditionally well functioning tourist trade, which tourist season consists of two segments – winter (lasting about 4 months) and summer (lasting about 3 months). Tourist facilities include a multitude of hotels, spas, ski and water sport facilities, hiking trails, parks and other natural preserved areas. Geothermal water in these areas is suitable for space heating of homes and other buildings, for swimming and balneological purposes, for the heating of ponds in which fish are raised and for greenhouse agriculture. Several geothermal wells (Vr-1, 2 Vrbov, FGP-1 Stará Lesná, PP-1 Poprad, ZGL-1 Bešeňová, ZGL-2 Liptovský Trnovec, ZGL-3 Liptovská Kokava, OZ-1, 2 Oravice) have been already drilled in the above mentioned areas (see tab. 3, 4). Some projects for these areas are being prepared.

Project of geothermal energy utilization in the town Žiar nad Hronom is based on knowledge about very good geothermal conditions in Žiar basin (Franko – Remšík – Fendek Eds., 1995). Geothermal water with temperature around 100 °C occurs at the depth of 2500 m in Triassic dolomites and limestones (Remšík et al., 1997). Heat demands of Žiar nad Hronom cover 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 natural gas. The boiler station in the ZSNP Inc. burns the black coal and produce high amount of the emissions of contaminants. The feasibility study was worked up for geothermal energy utilization for heating of the town and ZSNP Inc. factory. Several variants, evaluating different conditions, which will occur after implementation of geothermal energy heating in Žiar region, were solved in the feasibility study. Drilling of the first geothermal well (2500 m deep) in the town Žiar and Hronom started in January 1999.

Conclusion

The old history of utilization of geothermal energy in Slovak Republic is mainly the history of utilization of thermal springs. Many archaeological finds discovered at the site and in the surroundings of thermal springs indicate that man was attracted to settle in these friendly areas. Most admired in the literature of past centuries were the well-known spas: Piešťany, Trenčianske Teplice, Rajecké Teplice, Turčianske Teplice, Sklené Teplice, Vyhne, Sliač, but also Svätý Jur, Pezinok, Lipovce, Rudno, etc. First utilization of geothermal waters for energetic purposes is connected with space heating in spas and is dated to the year 1958.

The geothermal energy utilization changed qualitatively and quantitatively during the past ten years. These changes were enabled due to the high level of knowledge of hydrogeothermal conditions in Slovak Republic, started intensive international cooperation (educational, technical, economical) together with establishing of new professional companies. Very important support gave to the process also the interest of the Government of Slovak Republic by including the geothermal energy to the energetic conception of Slovak Republic.

Geothermal energy can be effectively used in the regions and localities as a local available source of heat in the case of lack of other energetic sources or increase of fossil fuels prices. In the case of favorable conditions geothermal energy can be also used as a source of the electric energy generation. According to sustainable resources management and environmental protection sources of geothermal energy were declared for one of the partial solutions which can substitute the fossil fuels. Mainly low enthalpy ($15 < t < 100$ °C), geothermal resources occur in territory of Slovak Republic.

Based on results of research and investigation in 70-ties and 80-ties, which were carried out by Dionýz Štúr Institute of Geology, 26 potential geothermal areas and structures were defined on the territory of Slovakia. Research, prospecting and exploration of geothermal waters has so far been carried out in 14 prospective areas. In the other 12 prospective areas, geothermal waters have not been verified by wells, but 6 of them have been geologically assessed for the purpose of prospecting and exploration for geothermal water. The total amount of thermal-energy potential of geothermal waters in prospective areas (proven, prognostic and probable) represents 5538 MW_t and is given on tab. 1 (Franko, Remšík & Fendek Eds., 1995).

The cooperation with foreign experts and companies begun very quickly. Based on this cooperation, first feasibility studies and realization projects were created. The first geothermal project - construction of reinjection plant in Podhájska, was finished in 1994. In 1996 the first geothermal heating plant, with capacity of 8 MW_t, in the Galanta town started to work. In 1998 the first three wells from the considered 8 doublets were drilled in the Košice basin. An installation of 110 MW_t source that would be used as a thermal power plant for central heat supply for Košice town with overall capacity of 700 MW_t is considered. In January 1999 first of 4 wells started to be drilled in the town Žiar nad Hronom in Žiar basin. 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 (Skorušina, Poprad, Liptov basin, etc.). Till December 1998 an amount of 130.97 MW_t had been practically utilized. Conditions for utilization of 180 MW_t before the year 2000 are being created.

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