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COUNTRY UPDATE OF THE SLOVAK REPUBLIC

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ABSTRACT

Geothermal energy in the territory of the Slovak Republic is related to geothermal waters which largely occur in Triassic carbonates of Inner Western Carpathian nappes and, to a lesser extent in Neogene sands, sandstones and conglomerates or in Neogene andesites and related pyroclastics. The distribution of aquifers with geothermal waters and the thermal manifestation of hydrogeothermal structures have enabled the definition of 26 prospective areas and structures with potentially exploitable geothermal energy resources. These aquifers lie at depths of 200 – 5000 m (except in spring areas) and the reservoir temperatures of their geothermal waters range from 20 to 240 °C. The total amount of thermal energy potential of geothermal waters in prospective areas represents 5538 MW_t.

1. INTRODUCTION

Renewable energetic sources like the 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 the Slovak Republic. The energetic potential of these sources represents about 4 % of the primary energetic sources utilizable in the years 2005 - 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 favourable conditions geothermal energy can be also used as a source of the electric energy generation. According to the sustainable resources management and environmental protection, sources of geothermal energy were declared as one of the partial solutions which can substitute for fossil fuels.

In the year 1996 the Ministry of the Environment together with the Ministry of the Economy of the Slovak Republic worked out the „Conceptual proposal of geothermal energy utilization in the Slovak Republic" to which the Government of the Slovak Republic accepted the „Resolution". In this Resolution the Government obliged the Minister of the Environment to provide the evaluation of geothermal energy utilization in the Central Depression of the Danube Basin (locality Galanta), Poprad Basin, Liptov Basin and Skorusina Depression, to prepare the hydrogeothermal evaluation of the Ziar Basin and to work out the study of possibilities for implementation of the „hot dry rock" project in the territory of the Slovak Republic.

Low enthalpy (temperature in the range 15 °C - 100 °C), medium enthalpy (100 °C - 150 °C) and high enthalpy (higher than 150 °C) geothermal resources occur in territory of the Slovak Republic. The most frequent of these are low enthalpy and the least are high enthalpy geothermal resources. The 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 the Slovak Republic in the near and far future (Fendek et al., 1999a, Franko, 1999).

2. UTILIZATION OF GEOTHERMAL ENERGY

2.1 Historical background

The history of utilization of geothermal energy in the 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: Piestany, Trencianske Teplice, Rajecke Teplice, Turcianske Teplice, Sklene Teplice, Vyhne, Sliac, but also Svaty Jur, Pezinok, Lipovce, Rudno, etc.

Though thermal springs were known as early as in the Middle Ages, the first geothermal well drilled in the territory of the Slovak Republic was the well in Ganovce drilled to the depth of 183 m in the year 1879. The value of free outflow from the well was 13.5 l/s of geothermal water with temperature of 24 °C. The second geothermal well followed in 1899 in Kovacova. The free outflow from the depth of 473 m was 12.5 l/s with temperature of 40.5 °C (Fendek et al, 1999).

The 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 Piestany, Kovacova, Sklene Teplice,
- utilization of heat pumps in Piestany and Turcianske Teplice,
- space-heating and heating of hot service water through heat exchangers in Piestany, Turcianske Teplice and Kovacova.

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

2.2 Present state

Based on results of research and investigation in 70s and 80s, which were carried out by Dionyz Stur Institute of Geology, 26 potential geothermal areas and structures were defined in 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 six of them have been geologically assessed for the purpose of prospecting and exploration for geothermal waters. Spatial distribution of potential geothermal areas and structures in the

territory of the Slovak Republic is shown in Figure 1. The total amount of thermal energy potential of geothermal waters in the prospective areas (proven, predicted and probable) represents 5538 MW_t and is given in Table 1 (Franko et al., 1995).

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 four localities for heating of service buildings, in one locality for sport hall heating, in two localities for fish farming, in one 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 (Table. 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.

It follows from Table 2 that the highest amount of the utilized sources of geothermal waters is situated in Trnava county and represents 44.47 MW_t (Fendek et al., 1999a). One of them is also Galanta installation. The possibility to obtain geothermal water for the purpose of power utilization in Galanta has been verified by the research geothermal borehole FGG-2 Galanta. The Dionyz Stur Institute of Geology Bratislava drilled 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, s.p. Zilina company (Franko et al., 1985). The temperature of the rock environment in the depths of 1000 and 2000 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 amounts to 77 °C.

In 1996 the first geothermal heating plant, with capacity of 8 MW_t, in the Galanta town was put on line. Galantaterm Ltd. – a legal entity has been formed to supply the 1236 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 provide the heat and hot service water. A natural-gas boiler house is used to heat the water when average daily temperature drops 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: 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 the flats (Fendek and Halas, 1997).

The second highest amount of utilized sources of geothermal waters is situated in Nitra county and represents 40.13 MW_t. The most important installation in Nitra county is the Podhajska reinjection plant which was finished in 1994. Two wells were drilled in Podhajska, which belongs to the hydrogeothermal structure of Levice block. The first one is exploits well Po-1 and the second one the reinjection well GRP-1 Podhajska. They create the first geothermal doublet being drilled in Slovak Republic. They are 1900 and 1470 m deep, with the discharge (free outflow) of 53.0 and 28.0 l/s and with the water temperature of 82 and 69.5 °C.

The total thermal energy potential of geothermal water of the Levice block, estimated by a two-dimensional numerical model, is 126 MW_t (Fendek, 1998). Geothermal water is utilized for space heating of a hotel with 86 beds, administrative building and greenhouses with the area of 3.2 ha. Swimming pools are also supplied by geothermal water.
The third highest amount of utilized sources of geothermal waters is situated in Zilina county and represents 25.56 MW_t. The most important installation in Zilina county is located at Besenova in Liptov Basin. Geothermal activity in the Liptov Basin is mediate. At the depth of 1000 m the temperature varies from 45 °C in Besenova horst to 30 °C on the periphery. Heat flow density in the regional geothermal field decreases from at least 70 mW/m^2 in the Besenova horst to 60 mW/m^2 in the west and less than 50 mW/m^2 in the Liptovska Kokava depression in the east. Geothermal waters flowing up from a depth of more than 1500 m to the surface heat the Besenova horst. In contrast, the margins of the Liptov Basin are cooled by adjacent mountains and in the Liptovska Kokava area also by cold karst waters.

Evidence of geothermal activity in the area is comprised of natural thermal springs at Besenova, Liptovska Stiavnica, Liptovske Sliace, Liptovsky Jan and Lucky villages with temperatures in the range from 20 to 32 °C.

Four geothermal wells were drilled in Liptov Basin with the depth of 1987 – 2500 m, three of them had the discharge of 20 – 27 l/s, the last one had a pumping rate of 6 l/s. The temperature of geothermal waters varies from 32 to 62 °C (Remsik et al., 1994).

The total amount of thermal energy potential of geothermal waters in Liptov Basin was evaluated by geothermic balance method and by numerical modelling. Both methods gave approximately the same value of about 34.3 MW_t (Fendek et al., 1999b).

In the year 1997 space heating of a hotel and greenhouses with the area of 1.8 ha in Besenova has started. The number of swimming pools has increased from two to five.

2.3 Prospects of geothermal energy utilization

Geothermal energy utilization projects prepared and partially realized in Kosice, Poprad, Liptov, Skorusina and Ziar 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 Dionyz Stur Institute of Geology in The Atlas of Geothermal Energy of Slovakia (Franko et al., 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.

The prospective part of Kosice basin with geothermal waters favourable for electric power production occupies 200 km^2. It is the area around the village Durkov. The source of geothermal water with temperature 115 - 150 °C from the depth interval 2100 - 3200 m as indicated by the oil and gas investigation. Remsik and Fendek (1992) developed the first project for a pilot geothermal well at the locality. Later, Geoterm-Kosice Ltd. Kosice was established to implement the project. For this project the detailed realization study was prepared (Vana, 1997). The object of the project is the utilization of geothermal heat in the amount of 100 - 110 MW_t for heating of the Kosice 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 annual utilization of 5000 TJ. The thermal power will be produced by eight production and eight reinjection wells. In the present time the first three wells were realized in the Kosice basin (Halas et al., 1999). They verified and confirm the assumption of geothermal waters in carbonate reservoir of the Kosice basin. Start of the operation is being planned for June 2001.

Projects of geothermal energy utilization in Poprad, Liptov and Skorusina basins have to support traditionally well functioning tourist trade, which tourist season consists of two segments – winter (lasting bout four 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 heating. Several geothermal wells (Vr-1, 2 Vrbov, FGP-1 Stara Lesna, PP-1 Poprad, ZGL-1 Besenova, ZGL-2 Liptovsky Trnovec, ZGL-3 Liptovska Kokava, OZ-1, 2 Oravice) have already been drilled in the above mentioned areas. Some projects for these areas are being prepared.

Project of geothermal energy utilization in the town Ziar nad Hronom is based on knowledge about a very good geothermal conditions in Ziar basin (Franko et al., 1995). Geothermal water with temperature around 100 °C occurs at the depth of 2500 m in Triassic dolomites and limestones (Remsik et al., 1997). Heat demands of Ziar nad Hronom cover two individual systems of central heating, one is supplied with hot water from ZSNP (Aluminium plant) boiler station and the second system is based on delivery of the natural gas. The boiler station in the ZSNP Inc. burns black coal and produces high amounts 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 Ziar region, were solved in the feasibility study. Drilling of the first geothermal well (2500 m deep) in the town Ziar nad Hronom started in the beginning of 1999.

3. CONCLUSION

The first utilization of geothermal waters for energetic purposes in Slovak Republic is connected with space heating in spas dates to the year 1958.

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

Based on results of research and investigation in 70s and 80s, which were carried out by Dionyz Stur 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 six 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, predicted and probable) represents 5538 MW_t and is given in Table 1 (Franko et al., 1995).

The first geothermal project - construction of reinjection plant in Podhajska, was finished in 1994. In 1996 the first geothermal heating plant, with capacity of 8 MW_t, in the Galanta town started to work. Space heating of a hotel and greenhouses started in Besenova in 1997. In 1998 the first three wells from the eight doublets were drilled in the Kosice basin. An installation of 110 MW_t source that would be used as a thermal power plant for central heat supply for Kosice town with overall capacity of 700 MW_t is considered. In the beginning of 1999 the first of four wells started to be drilled in the town Ziar nad Hronom in Ziar basin. The 30 MW_t geothermal heating plant will supply the heat for 27000 habitants of this town. The feasibility studies are prepared for several localities in the territory of Slovakia (Skorusina, Poprad, Liptov basin, etc.). Till June 1999 an amount of 130.97 MW_t has been utilized. Conditions for utilization of 180 MW_t before the year 2000 are being created.

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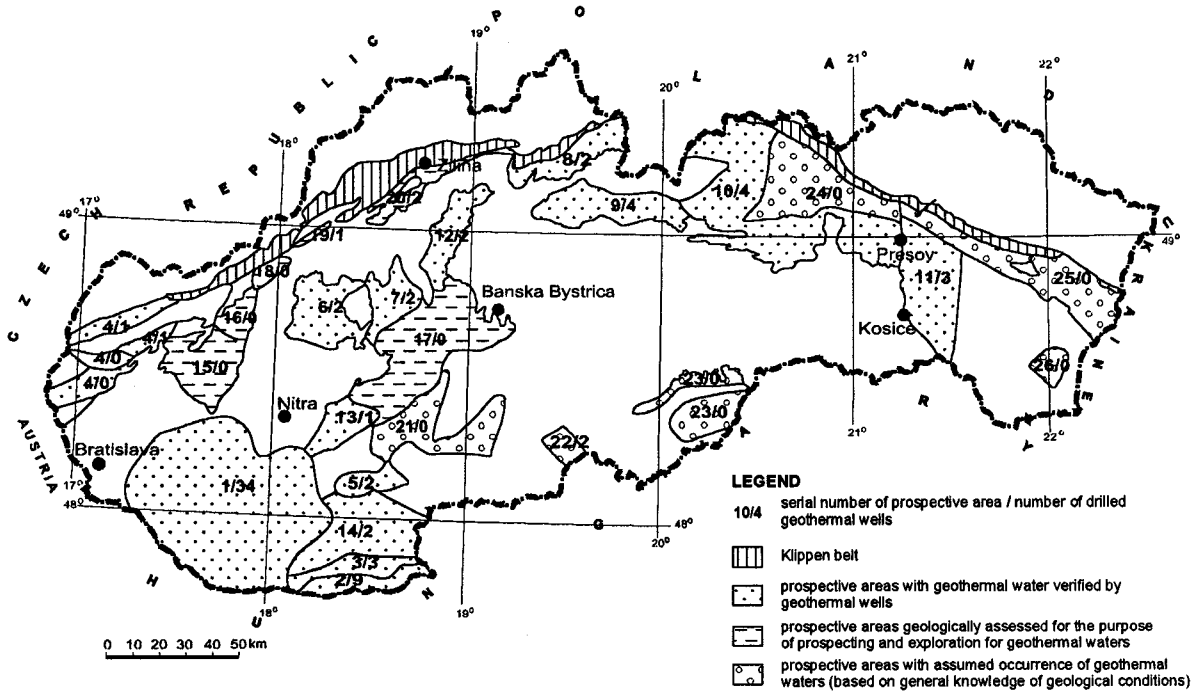

Figure 1. Distribution of potential geothermal areas and structures in the territory of Slovak Republic
1-Danube Basin central depression, 2-Komarno high block, 3-Komarno marginal block, 4-Vienna Basin, 5-Levice marginal block, 6-Banovce Basin and Topolcany embayment, 7-Upper Nitra Basin, 8-Skorusina Basin, 9-Liptov Basin, 10-Levoca Basin (W and S parts), 11-Kosice Basin, 12-Turiec Basin, 13-Komjatice depression, 14-Dubnik depression, 15-Trnava embayment, 16-Piestany embayment, 17-Central Slovakian Neogene volcanics (NW part), 18-Trencin Basin, 19-Ilava Basin,

20-Zilina Basin, 21-Central Slovakian Neogene volcanics (SE part), 22-Horne Strhare – Trenc Graben, 23-Rimava Basin, 24-Levoca Basin (N part), 25-Humenne ridge, 26-Besa – Cicarovce structure

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

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

Table 2. Distribution of utilized geothermal energy sources in counties of the Slovak Republic (till 30.06.1999)

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
Trencin	3	30.9	30.2	4.54	4.49
Zilina	5	312.6	184.0	35.25	25.56
Banska Bystrica	5	131.3	54.2	9.39	5.15
Presov	2	172.6	70.5	26.87	11.16
Kosice	1	195.6	0.6	33.54	0.01
Total amounts	36	1672.0	846.4	269.95	130.97

SUMMARY TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in January 2000	-	-	1963.4	5615	2393.1	4693	2200	13117	6556.5	23425
Under construction in January 2000	-	-	-	-	-	-	440	2723	440	2723
Funds committed but not yet under construction in January 2000	4	6	228	685	15.2	75.8	-	-	247.2	766.8
Total projected use by 2005	4	6	2082	6300	2408.3	4040	2640	15840	7134.3	26186

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF DECEMBER 1999

Locality	Type	Maximum Utilization			Annual Utilization	
		Flow Rate l/s	Temperature [°C] Inlet	Outlet	Average Flow Rate l/s	Energy Use TJ/yr
Komarno	B	5	40	33	4	3.7
Sturovo	B	70	40	28	15	23.7
Kralova pri Senci	B/G	13	52	41	5	7.2
Topolniky	D/B/G	23	74	35	12	61.7
Galanta-1	B	10	61	35	10	34.3
Galanta -2,3	D	50	80	40	20	105.5
Tvrdosovce	B/G	20	70	34	15	71.2
Horna Poton	G	20	68	36	16	67.5
Vlcany	G	10	58	22	6	28.5
Gabcikovo	B	10	52	30	3	8.7
Dunajska Streda-1	G/B/D	15	91	40	10.5	70.6
Dunajska Streda-2	B	23	55	30	16	52.8
Calovo-1	G	10	73	44	8	30.6
Calovo-2	B	16	57	30	16	57.0
Diakovce	D/B	12	63	30	10	43.5
Nove Zámky	B	4	59	27	4	16.9
Sala	B	3	42	28	3	5.5
Cilizska Radvan-1	G	6	82	32	6	39.6
Cilizska Radvan-2	G	17	64	32	12	50.6
Topolovec	G	10	61	35	10	34.3
Dunajsky Klatov	G	10	74	33	10	54.1
Podhajska	D/B/G	45	80	41	20	102.9
Besenova	D/B	27	62	40	18	52.2
Vrbov-1	F/B/D	28	55	33	20	58.0
Vrbov-2	F/B	33	59	33	15	51.4
Banovce n/Bebravou	B	23	46	20	15	51.4
Oravice	B	110	56	30	10	34.3
Total		**623**			**309.5**	**1217.7**

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF DECEMBER 1999

Locality	Ground or water temp. (°C)	Typical Heat Pump Rating or capacity (kW)	Number of Unites	Type	COP	Equivalent Full Load Hr/Year	Thermal Energy Used (TJ/yr)
Podhajska	40	20	1	W	3.8	3360	0.153
Bojnice	38	40	1	W	4.2	4350	0.273
V.Ruzbachy	19	778	2	W	3.7	11390	6.845
Gbelany	9	23	1	W	4.0	4550	0.115
Raj. Teplice	34	489	3	W	4.5	7600	4.725
TOTAL		**1350**	**8**			**31250**	**12.111**

TABLE 5. SUMMARY TABLE OF GEWOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 1999

	Installed Capacity [MW_t]	Annual Energy Use (TJ/yr)	Capacity Factor
Space Heating	15.2	277.5	0.579
Air Conditioning (Cooling)			
Greenhouse Heating	22.5	355.4	0.501
Fish and Animal Farming	2.3	36.2	0.499
Agricultural drying			
Industrial Process Heat			
Snow Melting			
Bathing and Swimming	90.9	1437.1	0.501
Other Uuses [specify]			
Subtotal	130.9	2106.2	0.510
Geothermal Heat Pumps	1.4	12.1	0.274
Total	**132.3**	**2118.3**	**0.508**

TABLE 6. WELLS DRILLED FOR DIRECT HEAT UTILIZATION OF GEOTHERMAL RESOURCES FROM JANUARY 1, 1995 TO DECEMBER 31, 1999.

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration	(all)	-	-	-	-	-
Production	>150 °C	-	-	-	-	-
	150-100 °C	-	2	-	-	5.350
	< 100 °C	-	1	-	-	3.616
Injection	(all)	-	1	-	-	3.200
Total		-	**4**	-	-	**12.166**

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTEHRMAL ACTIVITIES (Restricted to personnel with a University degrees

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
1995	4	2	1	1	1	5
1996	3	2	1		2	10
1997	3	2	1		4	11
1998	3	2	1		4	11
1999	3	2	1		4	11
Total	**16**	**10**	**5**	**1**	**15**	**48**

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (1999) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1985 – 1989	3.928	0.75	0.60	-	20	80
1990 – 1994	4.486	1.20	1.10	-	70	30
1995 – 1999	6.250	2.50	3.00	-	95	5