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CURRENT STATUS OF GEOTHERMAL ENERGY UTILIZATION IN ROMANIA

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Abstract

Exploration for geothermal resources began in Romania in the early 1960's, arising from a hydrocarbon research program, which, as an unexpected benefit, also identified eight promising geothermal areas. Within these areas, over 200 wells, drilled to depths between 800 and 3,500 meters, showed the presence of low enthalpy geothermal resources (40-120°C). Completion and experimental exploitation of over 100 wells during the past 25 years has enabled evaluation of the exploitable heat available from these geothermal resources. Proven geothermal reserves in Romania are currently about 200,000 TJ for 20 years.

The main Romanian geothermal resources are found in porous and permeable sandstones and siltstones (for example, in the Western Plain and the Olt Valley), or in fractured carbonate formations (Oradea, Bors, North Bucharest).

The total thermal capacity of the existing wells is about 480 MWt (for a reference temperature of 25°C). Of this total, only 145 MWt are currently used, from 96 wells (of which 35 wells are used for balneology and bathing) that are producing hot water in the temperature range of 45–115 °C. For 1999, the annual energy utilisation from these wells was about 2,900 TJ, with a capacity factor of 0.62. More than 80% of the wells are artesian producers, 18 wells require anti-scaling chemical treatment, and six are reinjection wells. The main direct uses of the geothermal energy are: space and district heating 39.7%; bathing 32.2%; greenhouse heating 17.1%; industrial process heat 8.7%; fish farming and animal husbandry 2.3%.

During 2000-2004, four geothermal wells have been drilled in Romania with National financing, and one additional well is in progress at this writing. All the four wells, drilled to depths ranging from 2,000 m to 3,000 m, have been successful, producing geothermal water with 37-84°C wellhead temperatures.

1. INTRODUCTION

Romania, as many other Central and Eastern European (CEE) Countries, has significant low enthalpy (50-120°C) geothermal resources suitable for direct heat utilisation: space heating, tap water heating, greenhouse heating, fish farming, animal husbandry; aquaculture, health and recreational bathing, etc.

Until the 1970s, these resources have only been partially used, mainly for health and recreational bathing. The use of natural hot springs in the Pre-Carpathian area of Romania has been known since the time of the Roman Empire, when the Dacia province had famous health spas: Geoagiu, Herculane and Felix Spa. During the last hundred years, geothermal health bathing flourished especially in the Western part of Romania.

The geological exploration for hydrocarbon resources carried out in Romania after World War II had extensive budgets and, especially, the oil crisis of the early seventies gave a significant impulse to the identification of geothermal reservoirs including the evaluation of exploitable reserves; proven by boreholes. Many geothermal operations have been completed between 1975 and 1990, mainly for greenhouse heating, space and hot tap water heating, some industrial applications, and for health and recreational bathing.

The existence of both the resources and the consumers provide good opportunities for the development of direct uses of the geothermal energy. However, practical accomplishments of the last ten years are rather modest: Beius, Cighid, Oradea and Calimanesti. These projects were intended either for modernising the equipment and management of existing geothermal systems, or for the exploitation of new reservoirs. Some of these projects involved consultants from West European countries, and have been awarded financial support from the European Union. The completion of these projects took a long time and great efforts, as they required legal and financial conditions quite new for this part of Europe, where the countries were in different stages of the transition from a centrally planned to a free market economy.

The large majority of the geothermal projects currently operating in Romania have low efficiencies, lagging behind in technology, infrastructures and equipment may be regarded as obsolete. The delivered energy is much lower than the demand and the potential of the resources. The absence of an efficient management, the lack of adequate maintenance, and mainly the lack of funds required for the retrofitting of the geothermal operations did not allow the full development of the exploitable resources.

The development of direct uses of Romanian geothermal resources has been hindered considerably by the inevitable difficulties attending transition from a centrally planned to a free market economy. Moreover, inadequate knowledge of, and difficult access to the latest technology developments, as well as lack of know-how to identify and prepare relatively complex projects has hampered the development of geothermal resources more than would have been expected, given the demonstrated substantial resources and the substantial benefits deriving from geothermal use. As a result, current geothermal production falls far short of the country's considerable demonstrated potential because of non sustained production (self flowing mode instead of artificial lift) and the lack of injection into the source reservoir of the heat depleted brine. Some systems, on a limited basis though, are applying the doublet concept of heat mining (Oradea, Bors, Otopeni – all fissured carbonate reservoirs). Relatively low cost reinjection in sandstone reservoirs will become critical for the disposal of the heat dep-leted brine in many locations, due to new environ-ment protection legal regulations.

Other barriers for geothermal development are:

- Lack of fiscal support from the government;
- State subsidy for heat from fossil fuels reduces the competitiveness of geothermal energy;
- Lack of potential financing from municipalities for secondary network development;
- Low potential of the drilling companies to invest in well or network development;
- Restrictive credit policies of commercial banks.

The current Romanian legislation relevant to geothermal development is harmonized with European Union principles and supports renewable energies, among which geothermal is specifically mentioned. The mineral resources (including geothermal) are owned by the State, their exploration and exploitation being regulated by the Mining Law issued in 1998. The National Agency for Mineral Resources is the Governmental institution in charge with issuing exploration and exploitation permits (long term concession).

In 2003, the Romanian Government approved the "Strategy for the development of renewable energy sources", which sets short and medium term targets in accordance with the EU principles and directives. The Kyoto objectives imply for the European Union, between 2008 and 2012, a reduction by 8% of the greenhouse gases emission compared to the 1990 level (corresponding to about 600 million tons per year of CO_2 equivalent). The European Council Resolution on renewable energies of 8 June 1998 seeks a doubling of the share of renewables from 6% at present to 12% in 2010. These targets are also assumed by Romania, as it intends to join the European Union in 2007.

At present, except for hydro, all other renewable energy sources have minor contributions to the Romanian energy mix. The main energy sources are still fossil fuels. The first 700 MW unit is currently on-line, the second being expected to start operation in 2006.

Two companies are currently involved in geothermal operations. Foradex S.A., located in Bucharest, is state owned drilling company that has the exploration or exploitation concessions for the geothermal reservoirs located in the southern half of Romania (Banat county, Olt Valley, and Bucharest regions). Transgex S.A., located in Oradea, is also mainly a drilling company privatised in 2000, and has the exploration or exploitation concessions for the geothermal reservoirs located in the western part of Romania (mainly Bihor county).

A consulting company, Geofluid S.A., which is a French-Romanian joint venture, operates in Oradea too.

The University of Oradea has a Geothermal Research Centre, an International Geothermal Training Centre, and its Faculty of Energy Engineering offers undergraduate and graduate studies in renewable energies, including geothermal.

2. Geothermal resources

In Romania, thermal springs are the only manifestation of geothermal resources. From prehistory to the present, the human community continued to live near and develop a variety of geothermal areas: Oradea, Felix Spa, Herculane Spa, Geoagiu, Calan, Caciulata, Mangalia (Cohut and Arpasi, 1995).

The first geothermal well in Romania was drilled in 1885 at Felix Spa, near Oradea. The well was 51 m deep, with a flow rate of 195 l/s and a temperature of 49°C. This first well is still in operation. It was followed by the well drilled at Caciulata (in 1893 - 37°C), Oradea (in 1897 - 29°C) and Timisoara (in 1902 - 31°C).

The search for geothermal resources for energy purposes began in the early 60's, based on a detailed geological program for hydrocarbon resources (that had extensive budgets). There are over 200 wells drilled with depths between 800 and 3,500 m, that shows the presence of low enthalpy geothermal resources (40÷120°C), which enabled the identification of 9 geothermal areas, 7 in the Western part and 2 in the Southern part. The completion and experimental exploitation (considered as part of geological investigation) of over 100 wells in the past 25 years made possible the evaluation of exploitable heat from geothermal reservoirs. The proven reserves, with the already drilled wells, are estimated at about 200 PJ for the next 20 years. The total installed capacity of the existing wells is about 480 MW_t (for a reference temperature of 30°C). Out of this only 150 MW_t is currently used, from 67 wells that are producing hot water in temperature range of 55÷115°C.

For 1997, the annual energy utilisation for direct use was about 2,700 TJ, from which health and recreational bathing was 870 TJ, with a load factor of 63 %. The main direct uses of geothermal heat are: space and tap water heating for domestic uses 36%, health and recreational bathing 32 %, greenhouse heating 23%, industrial processes heat (wood and grain drying, milk pasteurisation, flax processing) 7%, fish farming 2%. More than 80 % of the wells are artesian producers, 18 of them require anti-scaling chemical treatment, and 5 are reinjection wells (Panu, 1995).

About 40 wells are used for health and recreational bathing in 16 spas that have a treatment capacity of over 850,000 people per year. In 1997, the average flow rate was 275 l/s, the water temperatures in the rage of 35÷65°C. The geothermal water is also used in 24 outdoor and 7 indoor pools.

During the last 5 years, four geothermal wells have been drilled to depths ranging from 2,000 m to 3,000 m, producing geothermal water with wellhead temperatures of 37-84°C. One new geothermal well is currently in drilling.

The geothermal systems discovered on the Romanian territory are located in porous permeable formations such as Pannonian sandstone, interbedded with clays and shales specific for the Western Plain, and Senonian specific for the Olt Valley. Some geothermal systems are located in carbonate formations of Triassic age in the basement of the Pannonian Basin, and of Malm-Aptian age in the Moesian Platform (Figure 1).

<u>The Pannonian geothermal aquifer</u> is multilayered, confined and is located in the sandstones at the basement of the Upper Pannonian (late Neogene age), on an approximate area of 2,500 km^2 along the Western border of Romania, from Satu Mare in the North to Timisoara and Jimbolia in the South. The aquifer is situated at the depth of 800 to 2,100 m. It was investigated by 80 geothermal wells, all possible producers, out of which 37 are currently exploited. The thermal gradient is 45÷55°C/km. The wellhead temperatures are between 50 and 85°C. The minerali-sation of the geothermal waters is 4÷5 g/l (sodium-bicarbonate-chloride type) and most of the waters show carbonate scaling, prevented by downhole che-mical inhibition. The combustible gases, mainly me-thane, are separated from the geothermal water. The wells are produced mainly artesian, but also with downhole pumps.

The main geothermal areas are - from North to South - Satu Mare, Tasnad, Acas, Marghita, Sacuieni, Salonta, Curtici, Lovrin, Tomnatic, Sannicolau Mare, Jimbolia and Timisoara. The main uses are: heating of 31 hectares of greenhouses; space hating of 2,460 flats and sanitary hot water preparation for 2,200 flats; industrial uses in 7 places (crop drying, hemp processing, ceramics drying, timber drying (Bendea and Rosca, 1999).

<u>The Oradea geothermal reservoir</u> is located in the Triassic limestone and dolomites at depths of 2,200∏3,200 m, on an area of about 75 km2, and it is exploited by 12 wells with a total flow rate of 140 l/s geothermal water with well head temperatures of 70∏105∞C. There are no dissolved gases, and the mineralisation is lower than 0.9∏1.2 g/l. The water is of calcium-sulphate-bicarbonate type. Both aquifers, the Triassic aquifer Oradea and the Cretaceous aquifer Felix Spa, are hydrodynamically connected and are part of the active natural flow of water. The water is about 20,000 years old and the recharge area is in the Northern edge of the Padurea Craiului Mountains and the Borod Basin. Although there is a significant recharge of the geothermal system, the exploitation with a total flow rate of 300 l/s generates pressure draw down in the system that is prevented by reinjection. Reinjection is the result of successful completion and beginning operation of the first doublet in the Nufarul district in Oradea city, in October 1992 (Lund, 1997). The Felix Spa reservoir is currently exploited by six wells, with depths between 50 and 450 m. The total flow rate available from these wells is 210 l/s. The geothermal water has a wellhead temperatures of 36∏48∞C and is potable. The annual utilisation of geothermal energy in Oradea is 415 TJ, representing 15% of the total geothermal heat produced in Romania.

<u>The Bors geothermal reservoir</u> is situated about 6 km north-west to Oradea. This reservoir is completely different from the Oradea reservoir, although both are located in fissured carbonate formations. The Bors reservoir is a tectonically closed aquifer, with a small surface area of 12 km2. The geothermal water has 13 g/l TDS, 5 Nm3/m3 GWR and a high scaling potential. The dissolved gasses are 70% CO2 and 30% CH4. The reservoir temperature is higher than 130∞C at the average depth of 2,500 m. The artesian production of the wells can only be maintained by reinjecting the whole amount of extracted geothermal water. At present, three wells are used to produce a total flow rate of 50 l/s, and two other wells are used for reinjection, at a pressure that does

not ex-ceed 6 bar. The geothermal water is used for heating 12 ha of greenhouses. The dissolved gasses are par-tially separated at 7 bar, which is the operating pres-sure, and then the fluid is passed through heat ex-changers before being reinjected. The installed power is 15 MWt, and the annual energy savings is 3,000 toe.

Figure 1: Location of the Romanian geothermal reservoirs

<u>The Beius geothermal reservoir</u> is situated about 60 km south-east of Oradea. The reservoir is located in fissured Triassic calcite and dolomite 1,870 – 2,370 m deep. The first well has been drilled in 1996 down to 2,576 m. A line shaft pump was set in the well in 1999, now producing up to 45 l/s geothermal water with 84°C wellhead temperature. A second well has been drilled in early 2004, and a line shaft pump was being installed at the time of this writing. The geothermal water has a low mineralization (462 mg/l TDS), and 22.13 mg/l NCG, mainly CO_2 and 0.01 mg/l of H_2S. At present, the geothermal water from the first well is used to supply district heating to part of the town of Beius (5 substations in the block of flats area, a hospital, two schools, etc.). The second well is being connected to the system and will supply 5 more substations. The company having the exploitation concession for the Beius reservoir (Transgex S.A.) intends to drill one more production well and a reinjection well in the area, and connect the entire town to the geothermal district system.

<u>The Ciumeghiu geothermal reservoir</u> is also located in the Western Plain, 50 km South to Oradea. The geothermal water is produced in artesian discharge, having a wellhead temperature of 105°C and 5-6 g/l TDS, with strong carbonate scaling prevented by chemical inhibition at the depth of 400 m. The aquifer is located in Lower Pannonian age gritstone, at an average depth of 2,200 m. The main dissolved gas is CH_4, the GWR being 3 Nm^3/m^3. The reservoir was investigated by 4 wells, but only one was in use until the greenhouses in the area have been closed, with a capacity of 5 MW_t (of which 1 MW_t from the separated combustible gasses). There are some chances for the greenhouse to re-start operation in the future.

<u>The Cozia-Calimanesti geothermal reservoir</u> (Olt Valley) produces artesian geothermal water, with a flow rate of 10÷20 l/s and wellhead pressure of 16÷20 bar, from fissured siltstones of Senonian age. The reservoir depth is 1,900÷2,200 m, the well head temperature is 90÷95°C, the TDS is 14 g/l, and there is no scaling. The GWR is 2.0 Nm^3/m^3 (90% methane). Although the reservoir was exploited for 10 years, there is no interference between the wells and no pressure draw down. The thermal potential possible to be achieved from the 3 wells is 18 MW_t (3.5 MW_t from gases), but only 8 MW_t is used at present. The energy equivalent gained in this way is 2,500 toe/year. The utilisation is mainly for space heating, but also for health and recreational bathing.

The Otopeni geothermal reservoir is located North to Bucharest. It is only partially delimited (about 300 km^2). The 13 wells that were drilled show a huge aquifer located in fissured limestone and dolomites. The aquifer, situated at a depth of 1,900÷2,600 m, belongs to the Moessic Platform. The geothermal water has temperatures of 58÷78°C, and 1.5÷2.2 g/l TDS, with a high content of H_2S (over 25 ppm). Therefore, reinjection is compulsory. The production is carried out using downhole pumps, because the water level in the wells is at 80 m below surface. The total flow rate is 25÷30 l/s. At present, only 3 wells are in production (5 MW_t), for heating 1,900 dwellings (annual savings 1,900 toe), and 2 wells are used for reinjection. The development is hampered by technical and, mostly, by financial difficulties. It is to be mentioned that there are potential users, and 6 wells are already drilled, the last 2 wells being situated near the Snagov Lake, producing water with temperatures of 75÷80°C, and significant flow rates.

Table 1: The main parameters of the Romanian geothermal systems

Parameter	U/M	Oradea	Bors	Beius	Western Plain	Olt Valley	North Bucharest
Type of reservoir		carbonate	carbonate	carbonate	sandstone	gritstone	carbonate
Area	km^2	75	12	47	2,500	28	300
Depth	km	2.2÷3.2	2.4÷2.8	2.4÷2.8	0.8÷2.1	2.1÷2.4	1.9÷2.6
Drilled wells	(total)	14	6	2	88	3	11
Active wells		12	5	1	37	2	5
Well head temp.	°C	70÷105	115	84	50÷85	92÷96	58÷75
Temperature gradient	°C/100	3.5÷4.3	4.5÷5.0	3.3	3.8÷5.0	4.6÷4.8	2.8÷3.4
TDS	g/l	0.8÷1.4	12÷14	0.46	2÷7	13	2.2
GWR	Nm^3/m^3	0.05	5÷6.5	-	0.5÷2.5	2÷2.8	0.1
Type of production		Artesian	Artesian	Pumping	Art. + Pump.	Artesian	Pumping
Flow rate	l/s	4÷20	10÷15	13÷44	4÷18	12÷25	22÷28
Operations		11	2	1	37	2	2
Annual savings	toe	9,700	3,200		18,500	2,600	1,900
Total installed power (with existing wells)	MW_t	58	25	10	210	18	32
Exploitable reserves (for 20 years)	MW/day	570	110	52	4,700	190	310
Main uses:							
space heating	dwellings	2,000	-	10,500	2,460	600	1,900
sanitary hot water	dwellings	6,000	-	3,200	2,200	600	1,900
greenhouses	ha	1.8	6	-	34	-	-
industrial uses	operations	6	-	-	7	-	-
health bathing	operations	5	-	-	8	3	2

3. Utilisation of geothermal energy

Due to the difficulties encountered by the economy, only three new geothermal projects were completed during 1999-2004: one for direct use and two for bathing and swimming. Most of the geothermal operations completed before 1999 continued to operate, with some exceptions where the users closed their operations (mainly greenhouses, the total area decreasing by almost 50%). The geothermal energy utilisation as of 31 December 2004 is shown in Table 2. Out of the 96 wells operated in 38 locations, 37 are exclusively used for health and recreational bathing, with a total maximum flow rate of about 890 kg/s.

Table 2: Utilisation of geothermal energy for direct heat as of 31 December 2004

Locality	Type	Maximum Utilisation			Capacity		Annual Utilisation	
		Flow Rate	Temperature (°C)			Ave. Flow	Energy	Capacity
		(kg/s)	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor
Satu Mare	HB	12	65	30	1.8	7	32.3	0.56
Carei	BI	5	45	30	0.3	3	5.9	0.62

Acas	GB	15	65	30	2.2	8	36.9	0.53
Tasnad	HBG	10	70	25	1.9	7	41.5	0.69
Beltiug	B	6	75	30	1.1	4	23.7	0.68
Sacuieni	HBGFI	8	80	25	5.1	12	87.1	0.54
Marghita	HB	6	65	25	2.0	10	52.8	0.83
Boghis	BH	12	45	25	1.0	10	26.4	0.83
Mihai Bravu	GF	6	65	25	1.0	0	0	0.00
Bors	G	25	115	40	7.8	0	0	0.00
Oradea	IHGBF	85	83	30	18.8	65	415.0	0.70
Livada	BF	10	88	35	2.2	5	35.0	0.50
Felix	BH	140	45	25	11.7	115	216.0	0.58
Madaras	BH	5	46	25	0.4	3	8.3	0.65
Ciumeghiu	G	12	92	35	2.9	0	0	0.00
Cighid	HBG	10	72	25	2.0	6	37.2	0.59
Beius	HB	44	83	30	9.7	15	104.9	0.34
Macea	HGB	15	65	25	2.5	8	42.2	0.53
Curtici	HGB	22	63	25	3.5	14	70.2	0.63
Dorobanti	GB	18	60	25	2.6	9	41.5	0.50
Sofronea	HB	6	42	25	0.4	3	6.7	0.53
Iratos	IB	5	40	20	0.4	3	7.9	0.63
Arad	B	12	40	25	0.8	7	13.8	0.54
Nadlac	IHB	10	78	30	2.0	8	50.6	0.80
Sannicolau	IHBG	50	78	30	10.0	35	221.6	0.70
Saravale	HB	8	75	25	1.7	5	33.0	0.61
Tomnatic	GB	45	80	30	9.4	22	145.1	0.49
Lovrin	HGB	40	81	30	8.5	30	132.0	0.49
Periam	HB	10	70	25	1.9	6	35.6	0.59
Jimbolia	IHGB	50	82	30	10.9	35	240.1	0.70
Teremia	IHB	15	85	30	3.5	6	43.5	0.39
Comlosu	HB	10	81	25	2.3	6	44.3	0.61
Grabat	IB	6	80	30	1.3	3	19.8	0.48
Beregsau	IB	6	75	25	1.3	3	19.8	0.48
Timisoara	HB	15	45	25	1.3	10	26.4	0.64
Herculane	B	75	52	25	8.5	50	148.0	0.55
Olt Valley	HB	25	92	30	6.5	16	130.8	0.63
N Bucharest	HB	35	62	25	5.4	15	65.0	0.38
TOTAL		889			156.6	659	2840.8	

Legend Table 2 (Type of utilisation):

H = Space heating & district heating (other than heat pumps)
I = industrial process heat
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
A = agricultural drying (grain, fruit, vegetables)
F = Fish and animal farming

The total capacity of the utilised wells is about 145 MW_t, which produces annually 2,841 TJ. The operations in Mihai Bravu, Bors and Ciumeghiu (Table 2) have been closed in the last years because the greenhouses in the area have been closed, but these are expected to resume in the short or medium term future. The greenhouses in Bors have been purchased by a private company and operation is expected to start in 2005. For this reason, these three locations have not been removed from Table 2, and their installed capacity has been added in column 6, giving therefore a total of 156.6 MW_t.

The main direct uses of geothermal heat are: space heating 39.7%, bathing and swimming including balneology 32.2%, greenhouse heating 17.1%, industrial process heat 8.7%, and fish farming and animal husbandry 2.3%, the capacity factor being 0.62. By type of utilisation, the actual situation in Romania is shown in Table 3.

During 1999-2004, four wells have been drilled with total depth of 11.7 km (Table 4), all financed from the State Budget within the framework of the national geological exploration program. Two were exploration wells, being drilled in areas not yet explored (by Foradex S.A., in the southern part of Romania, one in the Olt Valley area, and one in the Bucharest area), and two were drilled in areas where already geothermal resources were identified (Beius and Olt Valley).

Out of the 4 wells drilled in the last five years, only one has rather low parameters (10 l/s by a line shaft pump, 37 ºC wellhead temperature), being mainly used for health and recreational bathing at a hotel near Bucharest in an outdoors swimming pool.

The other three wells had flow rates and temperatures that qualify them for energy uses. The new well drilled in Beius has a well head temperature of 84°C (as expected, being the second well drilled in that reservoir). The plan is to set a line shaft pump in the well in 2004. The geothermal energy available geothermal to develop the existing geothermal district heating system by connecting 3 more substations, one hospital, 2 schools, etc.

Feasibility studies for direct use projects on the other two new wells are currently carried out for district heating in Ramnicu Valcea (Olt Valley) and for a hospital in Balotesti (close to Bucharest).

One more exploration well is planned to be drilled during 2004 in the western part of Romania by the Transgex S.A. Company, financed by the State Budget.

The Governmental institutions with activities related to geothermal resources are: the Romanian Geological Survey (exploration and resources information), the National Agency for Mineral Resources (resource database, award of exploration and exploitation licences), and the Ministry of Industry (Energy Department). The total men – year effort related to geothermal of all these institutions is estimated to be about 2 each year (Table 5).

Table 3: Summary table of geothermal direct heat uses as of 31 December 2004

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/yr)	Capacity Factor
Space Heating	57.2	1129	0.62
Greenhouse Heating	28.3	486	0.54
Fish and Animal Farming	3.1	65	0.66
Industrial Process Heat	14.1	246	0.55
Bathing and Swimming	42.2	915	0.68
TOTAL	144.9	2841	0.62

Table 4: Wells drilled for electrical, direct and combined use of geothermal resources from January 1, 1999 to December 31, 2004

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration	(all)	-	2 + 1?	-	-	5.0
Production	>150° C	-	-	-	-	-
	150-100° C	-	-	-	-	-
	<100° C	-	2	-	-	3.7
Injection	(all)	-	-	-	-	-
Total		-	4	-	-	8.7

There are no public utilities actually operating geothermal systems. Geothermal district heating systems are operated only by the two companies mentioned before (Transgex and Foradex). In all cases though, the distribution network is public property, according to the Romanian legislation. For this reason, the public utilities that have part or all their heat supplied form geothermal resources (e.g. the town of Beius) have at least one person in charge of supervising the geothermal part of the system.

The University of Oradea is a state university established under this name in 1990, based on different higher education institutions of which the first started its activity in 1780. Some of its faculties have geothermal related training and/or research among their activities, such as the Faculty of Energy Engineering, the Faculty of Environment Protection, the Faculty of Electrotechnics and Informatics, and the Faculty of Medical Sciences. The Faculty of Energy Engineering currently offers B.Sc. training in

Renewable Energy Resources and M.Sc. training in Geothermal and Solar Energy Utilisation. Five members of its current academic staff followed the six months UNU Geothermal Training Programme in Iceland. The university also has a number of research and training departments, including the Geothermal Research Centre and the International Geothermal Training Centre.

The number of employees with a University degree of Transgex S.A. increased slowly after 2000, when the company was privatised, as geothermal is currently its main business. In the last five years the company also paid foreign experts for consulting, whenever needed.

Foradex S.A. is a large state owned company. The main part of its activity is drilling (in Romania and abroad). It has a Geothermal Department, but no information was available regarding the employee structure. The project in Calimanesti for combustible gas separation was co-funded by the EC, and foreign consultants have also been partners in the project. The 1 man – year effort in Table 5, column 4, should therefore be considered as a cumulated value over 5 years for both companies (Transgex and Foradex), with the reserve of a rather gross estimate.

Table 5: Allocation of professional personnel to geothermal activities
(Restricted to personnel with University degrees)

Year	Professional Person - Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000	2	4	11	-	-	17
2001	2	3	11	-	-	17
2002	2	3	12	-	-	18
2003	2	3	12	-	-	20
2004	2	3	12	1	-	22
Total	10	16	58	1	-	94

Legend Table 5:

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

During 1999-2004, the investments in geothermal projects (Table 6) totalled 12.5 million USD, less than half as compared to 1990-1994 and 1985-1989, when all projects have been financed from public funds (mainly from the State Budget, geological exploration and research).

Out of the total investments in geothermal projects the cost of drilling the four wells represents 56% in the public funding type column in Table 5. Even the wells drilled in known reservoirs have been funded from the State Budget, as research needed to confirm the resource. This practice is expected to be abandoned in the near future, the exploration funds being only available for drilling wells in new areas.

The production well equipment for the two wells in Beius are (line shaft pumps, variable speed drives, automation, etc) has been financed from other funds the Transgex Company could raise (equity, commercial bank loans, European Commission grants, carbon credits, etc).

The capital investments for the direct use systems have all been considered as private funds, although Foradex is still state owned, as it operates on commercial basis and is open for privatisation.

Although the total investment decreased in the last 5 years as compared to the previous 5 years intervals, the new and important thing is that private capital almost equalled the public funding.

The Transgex Company started to develop in 2004 a new doublet type geothermal district heating system in one district of Oradea city, the total capital investment being estimated at about 1.8 million USD. This is not included in Table 6, as it is not yet completed.

Other projects of Transgex are planned to start in the 2005, and more are under consideration for the mid term future. Foradex intends to start new projects too.

Table 6: Total investments in geothermal in (1999) USD

Period	Research &Development Incl. Surface Exploration & Exploration Drilling Million US$	Field Development Including Production Drilling & Surface Equipment Million US$	Utilisation		Funding Type	
			Direct Million US$	Electrical Million US$	Private %	Public %

1985-1989	21	7	5	-	-	100
1990-1994	15	5	7	-	-	100
1995-1999	9	11	7	-	-	100
1999-2004	4.4	3.6	4.5	-	56	44

4. Future development plans

4.1 Transgex S.A.

The Nufarul district geothermal project aims to provide space heating and hot tap water in this district of Oradea City. There are currently 11 heating substations in Nufarul district. To 7 of them, the hot sanitary water is supplied by one well, and for the remaining four by the co-generation power plant of Oradea (CET 1, fired 65% by gas and 35% by lignite). All 11 substations use thermal energy supplied by CET 1 for space heating. The objective of this project is to supply the base load by geothermal energy. The pumped flow-rate of the existing well is 40 l/s, at a wellhead temperature of 72°C. The total heat demand is 367,158 GJ, so that two new wells needs to be drilled. Due to the existing space heating devices inside the flats (cast iron radiators), for high loads is necessary to heat up the space heating fluid in the secondary network from 70°C to 90°C in a natural gas fired peak load boiler. The annual heat demand for space heating is 260,000 GJ. The geothermal energy will cover 47%, and the peak load boiler 53% of the space heating demand. The hot sanitary water will be heated all year round by geothermal energy. The estimated capital investment is 4 million USD, including two new wells (for production and reinjection). The annual greenhouse gas emissions reduction resulting from the project will be 8,268 tons of CO_2. The selling price will be about equal to that from CET 1, but without the subsidies it still receives from both the local and the central budget.

The Beius town substations will be entirely connected to the geothermal district heating system. Transgex has currently completed the drilling of a new well with a depth of 2,800 m to connect additional consumers (blocks of flats, hospital, nursery, high school, pedagogical college as well as some institutions such as the Public Finances, or the Prosecutor's Offices). This additional withdraw from the same reservoir will require the drilling of a re-injection well in order to maintain reservoir parameters.

The Livada village (1300 inhabitants) is situated about 14 kilometers from Oradea. One well has been drilled and used earlier for fish farming and bathing. The well parameters are: artesian flow rate 10 kg/s; temperature: 90°C; energy potential 45,000 GJ/yr. Transgex is planning to build a geothermal station and a primary network in order to provide heating and sanitary hot water for the village inhabitants, pending on the county's commitment to build the secondary network. Transgex is also planning to establish a greenhouse facility that would use the return geothermal water. Total estimated cost for the project is 250,000 USD (excl. the greenhouse).

The Salonta town had a small district heating system, but all 4 substations are currently shut-down, most residential blocks being heated individually by wood. Gas is supplied to public institutions only. Transgex owns two wells, with a whole potential of 125,000 GJ/yr. that is suitable to provide sanitary hot water for the city's 20,000 inhabitants. The wells contain some dissolved gas (methane), and have scaling potential. Transgex plans to connect the wells to the sub-stations. The most significant users of geothermal energy would be the hospital, the college, schools and blocks of flats from the central area. The estimated capital investment cost of the project is about 600,000 USD.

In Marghita town, three production wells (68°C) have been drilled in 1970-72 for exploration purposes. One is used for heating a hotel and for a swimming pool; the second is used for heating a small company, while the third is unused. The wells contain dissolved gas, but have no scaling potential. The proposal is to expand geothermal heat supply to the hospital and to also connect buildings around the hospital. The total estimated cost: 85,000 USD.

The Bors geothermal reservoir has been used for heating the greenhouses in the area. There are 5 wells, of which 3 production and 3 reinjection (necessary, as the reservoir is confined and rather small). The reservoir supplies high temperature (120°C) water, but has a high scaling potential and contains dissolved gas (7 Nm^3/m^3, of which 75% CO_2). The currently artesian production (10 l/sec/well) could be increased to 30 l/sec/well by pumping. Transgex considers using this potential for supplying heat to an industrial park (not there yet but potential), to Bors Customs and to the village. An alternative envisaged use is for heating newly constructed greenhouses. The estimated investment for a completely new system is 750,000 USD.

The Sacuieni village has 7 geothermal wells with a total estimated potential of 400,000 GJ per year. Only a fraction of this huge potential is currently used (one well heating a bank and the police station). All former consumers have gone bankrupt. The proposal is to identify new consumers and expand the use of this potential.

Research projects: Two more sites (one in the Oradea – Bors area vicinity, on between Oradea and Beius) have also been considered for the drilling of exploration wells. Recent data suggest that geothermal wells with wellhead temperatures up to 150°C can be drilled to a depth about 5,000 m. There is a good chance for receiving funding for this research from the Government.

4.2 Foradex S.A.

The Olt Valley area:

Geothermal district heating and sanitary hot water with peak load boilers in Calimanesti town, using also the methane separated from geothermal water;

Ramnicu Valcea city - geothermal district heating and sanitary hot water with gas peak boilers – transmission pipe from the Olt valley.

The Banat area (south-west Romania):

Line shaft pump to increase production, rehabilitation and extension of the district heating network with natural gas fired peak load boilers in the Sannicolaul Mare village;

Green house heating, natural gas fired peak load boilers in the Tomnatic village.

The Bucharest area:

Geothermal district heating with fuel oil fired peak load boilers and water recreation complex in Snagov village;

Geothermal district heating with fuel oil fired peak load boilers, new transmission lines and new submersible pumps in Otopeni village;

Space and tap water heating for a hospital in Balotesti village.

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