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Geothermal Energy in Romania: Country Update 2005-2009

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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 some promising geothermal areas. Within these areas, over 250 wells, drilled to depths between 800 and 3,500 m, showed the presence of low enthalpy geothermal resources. 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 capacity of the existing wells is about 480 MW_t (for a reference temperature of 25°C). Of this total, only about 180 MW_t are currently used, from about 80 wells (of which 35 wells are used only for balneology and bathing) that are producing hot water in the temperature range of 40÷115°C. For 2009, the annual energy utilisation from these wells was about 1,235 TJ, with an average capacity factor of about 0.22. More than 80% of the wells are artesian producers, 18 wells require anti-scaling chemical treatment, and 6 are used for reinjection. The main direct uses of the geothermal energy are: space and district heating; bathing; greenhouse heating; industrial process heat; fish farming and animal husbandry.

During 2005-2009, 7 geothermal wells have been drilled in Romania with National financing. Some of these wells, drilled to depths ranging from 1,500 m to 3,000 m, have been successful, 3 of them producing geothermal water with about 70°C wellhead temperature, and one of them, near Oradea, about 1,700 m deep, with a wellhead temperature of about 90°C and an artesian flow rate of about 10 l/s right after completion, without acidizing.

1. INTRODUCTION

At present, the Romanian legislation is harmonized with European Union principles and supports renewable energy sources, geothermal being specifically mentioned.

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 Renewable Energy Roadmap adopted in 2007, which defines clear targets and goals to reach a 20% contribution of renewable energy to the energy mix by the year 2020, has also been adopted by Romania and included in the Energy Strategy for the 2007-2020 period. These targets are also mandatory for Romania, after joining the European Union in 2007.

The underground mineral resources (including geothermal) are owned by the State. The Romanian Constitution, adopted in 1991, stipulates that "resources of any nature occurring in the underground, [and] the water with useful energy content, etc., are exclusively public property." Mineral rights are excluded from private ownership. Their exploration and exploitation is regulated by the Mining Law (No. 61/1998, old version, , modified by Law no. 85/2003).

Obtaining concession licenses (from the National Agency for Mineral Resources, see below) for exploration and exploitation is regulated by the Concession Law No. 219/1998.

The Environment Protection Law (No. 137/1995 old version, modified by Law No. 265/2006), stipulates that the activity of drilling wells for underground fluid production is subject to the environmental authorization procedure. Only water wells for domestic use (residential areas, family houses) with depths of less than 50 m are excepted from this procedure. Wells for (vertical loop) borehole heat exchangers are not specifically mentioned (this is still an unusual technical solution in Romania, most ground source heat exchangers are horizontal, being less expensive). The drilling process is still under the incidence of the Environmental Protection Law for the storage and disposal of hazardous fluids (fuels, lubricants, drilling mud), as well as air and noise pollution.

The Water Law (No. 107/1996, old version, modified by Law No. 310/2004) regulates the use and protection of Romania's water resources. All waters - ground and underground - belong to the state. They can be used free for drinking, washing, irrigation and other needs, even in small installations, but can not be sold. Otherwise, the right of using both ground and underground waters is subject of authorization. In order to stimulate the development of small and medium enterprises Law No. 346/2004 stipulates that for some small size works and activities (flow rates below 36 m^3/h) a notification at the Competent Authority is enough.

The Thermal Energy Law No. 325/2006 sets the general rules for district heating systems, and is intended to stimulate the use of renewable energy sources, among which geothermal is specifically mentioned. According to this law, all district heating systems have to be public property, but the operation can be concessioned to a specialized private company or to a public - private joint venture. The district heating company purchases heat from any producer (public or private), transports, distributes and supplies it to consumers.

The Law for the Promotion of Energy Production from Renewable Energy Sources No. 220/2008 regulates all aspects regarding the "green certificates" issued for electric

and thermal energy produced from renewable energy sources, geothermal included. In general, for 1 MWh energy produced from a renewable source, the producers receives one green certificate. For 1 MWh thermal energy produced from geothermal energy the producer receives 1 green certificate, but for electric energy produced from geothermal energy the producer receives now 3 green certificates. Some restrictive conditions apply, different for some renewable energy sources, mainly as minimum or maximum installed capacity and first year of operation. The green certificates can be sold on the Green Certificates Exchange. The maximum price for one green certificate is, for 2009, 55 €. The producers of energy from fossil fuels have annual quotas of green certificates they have to acquire, function of their annual energy production, otherwise they have to pay a fine. These quotas are fixed for each year until 2020, and increase every year. As the available green certificates are much below the demand, their selling price is the maximum one. At the end of the year, the money obtained from fines is distributed to the green energy producers proportional to the number of green certificates they sold, providing an additional income on top of the one from the certificates.

The National Agency for Mineral Resources (NAMR), established in 1993, is the regulatory authority to administer the mineral resources as well as the Competent Authority which coordinates the mining operation under the Mining Law, according to the provisions of the Concession Law. In particular, the Agency is authorized to institute hydro-geological protection perimeters, for the underground waters (mineral and thermo-mineral), to negotiate the terms and conclude agreements for the exploration and production of mineral resources and to select, finance, and follow up on all geological exploration and exploitation works for geothermal resources.

The Order No. 97/20.05.2008 of the President of NAMR on the technical instructions for classifying and assessing the resources/reserves of natural mineral water, therapeutic mineral water, geothermal water, gases that accompany them, and noncombustible gases defines all these mineral resources, and geothermal waters are defined as “renewable useful mineral substance, represented by the totality of underground water which have the role of transporting the heat from the terrestrial crust, used for energy or as therapeutic mineral waters, with temperatures at the source higher than 20°C”.

The National Agency for Environment Protection, established by the Governmental Decision no. 1625/23.12.2003, is the responsible authority under the Environment Protection Law. It has been intended to work so as to ensure a healthy environment, in line with Romania's economical development and its social progress. Its mission consists in ensuring a better environment for the present and future generations, through a continuous enhancement of air, soil and water quality.

The National Administration “Romanian Waters” is the competent authority under the Water Law. Its competence goes to surface waters of the public domain as regulated by the Law of Waters no. 107/1996, with their minor beds, shorelines and lake basins as well as their natural resources and energy potential, underground waters, sea-walls and beaches, dams, reservoirs and others.

The competent authority for the Energy Efficiency Law is the Romanian Agency for Energy Conservation who is empowered to insure the implementation of the provisions of Law No. 199/2000 with regard to efficient use of energy, as republished, referring to the duty of energy consumers to designate their appointee for energy, to periodically carry on energy balances, identify measures for energy saving, and develop programs of energy efficiency. The Romanian Agency for Energy Conservation uses its mandate to establish a dialogue with energy consumers by insuring free consultancy with regard to modern techniques of energy saving and by increasing knowledge and sensibility about economic gains that may be obtained by making use of energy efficiency management practices.

The economic and technical operation and development of the energy sector (electric and thermal) is regulated, ruled, supervised and monitored by the National Regulatory Authority for Energy (NRAE), which was set up by an Emergency Ordinance in October 1998 as an independent and autonomous public institution. For electric energy, according to the current legislation, TRANSELECTRICA, (the National Power Transportation Company) has to purchase the entire available power produced from renewable resources at the price established by the NRAE, based on the financial and economic assessment study.

For thermal energy sold to a private commercial customer, the unit selling price is usually fixed by direct negotiation between the two parties. In case the customer is a public utility (e.g. district heating), the unit selling price has to be approved by the Local Council and also by the National Regulatory Agency for Local Administration.

There are two main companies in Romania currently exploiting geothermal resources, Transgex S.A. and Foradex S.A., which have the long term concession for practically all known geothermal reservoirs.

Transgex S.A. was established in 1970, having as main activities prospecting and geological exploration for mineral resources, by well drilling and mining works. Up to now, the company has drilled about 150 wells for geothermal water. The Transgex S.A. Company was privatised in 2000. At present, as basic activity, Transgex S.A. is developing the use of geothermal energy for district heating in the towns of Oradea, Beius, Salonta, Marghita, as well as in the villages Livada, Sacuieni, Cighid, Sinicolau de Munte, Santion. Geothermal energy is delivered in towns to blocks of flats, administrative institutions and economic agents, and in smaller communities to blocks of flats and administrative buildings.

Foradex S.A. is a large company privatised in 2008. The main part of its activity is drilling (in Romania and abroad). It has a Geothermal Department, has exploration or exploitation licences in the southern (North Bucharest, Olt Valley) and south-western part of Romania, but not much information is available regarding its activities.

Turism Felix S.A. is a tourist company owning most hotels in Felix Spa, near Oradea, as well as the geothermal wells and the exploitation licence. The geothermal water is only used for health and recreational bathing.

A few other (smaller) companies have exploration or exploitation licences for geothermal sources, the typical example being one low temperature well used for one or more swimming pools.

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 Electrical Engineering and Information Technology, and the Faculty of Medicine and Pharmacy. The Faculty of Energy Engineering currently offers B.Sc. training in Thermal energy engineering (strongly oriented to renewable energy sources) and M.Sc. training in Renewable energies. 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 centres, including the Geothermal Research Centre.

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 wells 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 250 wells drilled with depths between 800 and 3,500 m, that show the presence of low enthalpy geothermal resources (40÷120°C), which enabled the identification of many geothermal areas, most of them in the Western part and 3 in the Southern part of Romania. The completion and experimental exploitation (considered as part of geological investigation) of over 100 wells in the past 30 years made possible the evaluation of exploitable heat from geothermal reservoirs. More than 80 % of the wells are artesian producers, 18 of them require anti-scaling chemical treatment (Panu, 1995), and 6 are reinjection wells.

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 25°C). Out of this, only about 180 MW_t is currently used, from 96 wells that are producing hot water in temperature range of 40÷115°C.

For 2009, the average flow rate was about 287 l/s, the annual energy utilisation for direct use was about 1,235 TJ, with an average load factor of about 22%. 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.

During the last 5 years, seven geothermal wells have been drilled to depths ranging from 1,500 m to 2,800 m, of which Three were unsuccessful (dry or cold), and three are producing geothermal water with wellhead temperatures of about 70°C. The drilling of a new geothermal well started in late 2008, planned down to about 3,000 m (funds made available by the State Budget in late May) At 1,700 m the circulation loss was so high that it was impossible to drill deeper, so the well was completed and tested (without acidizing). It produced (in artesian discharge) about 10 l/s geothermal water with about 90°C wellhead temperature. This well will probably be used for district heating in the City of Oradea.

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).

Figure 1: Location of the main Romanian geothermal reservoirs

The Pannonian geothermal aquifer 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 2,400 m. It was investigated by more than 100 geothermal wells, all possible producers, out of which 37 are currently exploited. The thermal gradient is 45÷55°C/km. The wellhead temperatures range between 50 and 85°C. The mineralisation (TDS) of the geothermal waters is 4÷5 g/l (sodium-bicarbonate-chloride type) and most of the waters show carbonate scaling, prevented by downhole chemical inhibition. The combustible gases, mainly methane, are separated from the geothermal water and not used (yet). The wells are produced mainly artesian, and very few of them with downhole pumps.

The main geothermal areas are - from North to South - Satu Mare, Tasnad, Acas, Marghita, Sacuieni, Salonta, Curtici-Macea-Dorobanti, Nadlac, Lovrin, Tomnatic, Sannicolau Mare, Jimbolia and Timisoara. The main uses are: heating of 10 hectares of greenhouses; district heating for about 2,500 flats, only sanitary hot water supply for 2,200 flats, health and recreational bathing, and fish farming. Other applications, such as ceramics drying, timber drying; hemp and flax processing, went broke and stopped operations (Bendea and Rosca, 1999).

The Oradea geothermal reservoir is located in the Triassic limestone(s?) and dolomites at depths of 2,200÷3,200 m, on an area of about 75 km^2, 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, the mineralisation is 0.9÷1.2 g/l, the water being of calcium-sulphate-bicarbonate type. The Oradea Triassic aquifer is hydrodynamically connected to the Felix Spa Cretaceous aquifer, and together 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 over 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 wellhead temperature of 36÷48°C and is potable. The annual utilisation of geothermal energy in Oradea is about 427 TJ, representing almost 35% of the total geothermal heat produced in Romania.

The Bors geothermal reservoir is situated about 6 km north-west of 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 km^2. The geothermal water has 13 g/l TDS, 5 Nm^3/m^3 GWR, and a high scaling potential, prevented by chemical inhibition. The dissolved gasses are 70% CO_2 and 30% CH_4. The reservoir temperature is higher than 130°C at the average depth of 2,500 m. The artesian production of the wells could only be maintained by reinjecting the whole amount of extracted geothermal water, and of colder water from shallower wells during the summer. In the past, three wells were used to produce a total flow rate of 50 l/s, and two other wells were used for reinjection, at a pressure that did not exceed 6 bar. The geothermal water was used for heating 12 ha of greenhouses (now bankrupt, stopped operation). The dissolved gasses were partially separated at 7 bar, which is the operating pressure, and then the fluid is passed through heat exchangers before being reinjected. The installed power is about 8 MW_t, and the annual energy savings was about 3,000 toe. This reservoir is currently not exploited at all.

The Beius geothermal reservoir 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 83°C wellhead temperature. A second well has been drilled in early 2004, and a line shaft pump was being installed later that year and can also produce up to 45 l/s geothermal water with 85°C wellhead temperature. The geothermal water from these wells 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. The geothermal water from both wells is currently used to supply district heating to part of the town of Beius (for a district heating system with 10 substations supplying a block of flats area, two hospitals, two schools, public buildings, etc.).

The Ciumeghiu geothermal reservoir is also located in the Western Plain, 50 km South to Oradea. The geothermal water has a wellhead temperature of 105°C and high mineralization (5-6 g/l TDS), with strong carbonate scaling potential (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). The geothermal water was used for heating greenhouses (bankrupt, stopped operation).

The Cozia-Calimanesti geothermal reservoir (Olt Valley) produces artesian geothermal water, with flow rates between 8.5 and 22 l/s, and shut-in wellhead pressures of 30÷33 bar, from fissured siltstones of Senonian age. The reservoir depth is 2,700÷3,250 m, the well head temperature is 70÷95°C, the TDS is 15.7 g/l, and there is no major scaling (only minor deposition and some corrosion were observed during years of operation). The GWR is 1÷2.0 Nm^3/m^3 (90% methane). Although the reservoir was exploited for more than 25 years, there is no interference between the wells and no significant pressure draw down. The thermal potential possible to be achieved from the 4 wells is about 14 MW_t (of which 3.5 MW_t from the combustible gases – if used), but only about 7 MW_t is used at present. The energy equivalent gained in this way is 3,500 toe/year. The geothermal water is mainly used for district heating (2,250 equivalent flats), and for health and recreational bathing.

Table 1: The main parameters of the most important Romanian geothermal systems

Parameter	U/M	Oradea	Bors	Beius	Western Plain	Olt Valley	N Bucharest
Type of reservoir		carbonate	carbonate	carbonate	sandstone	gritstone	carbonate
Area	km^2	75	12	47	2,500	10	350
Depth	km	2.2÷3.2	2.4÷2.8	2.4÷2.8	0.8÷2.39	2.7÷3.25	2.0÷3.2
Drilled wells	(total)	14	6	2	88	4	17
Active wells		12	0	2	39	2	1
Well head temp.	°C	70÷105	120	84	50÷90	70÷95	51÷84
Temperature gradient	°C/100	3.5÷4.3	4.5÷5.0	3.3	3.75÷4.15	3.0÷3.5	2.3÷2.6
TDS	g/l	0.8÷1.4	12÷14	0.46	2÷6	15.7	2.2
GWR	Nm^3/m^3	0.05	5.0÷6.5	-	0.6÷2.1	1÷2	0.1
Type of production		Artesian	Artesian	Pumping	Art. + Pumping	Artesian	Pumping
Flow rate	l/s	4÷20	10÷15	13÷44	4÷12	8.5÷22	22÷28
Operations		11	2	1	18	3	1
Annual savings	toe	9,700	3,200		18,500	3,500	1,900
Total installed power	MW_t	58	25	10	30	12.5	35
Exploitable reserves (20 years)	MW/day	570	110	52	4,700	300	840
Main uses:							
• space heating	dwellings	2,000	-	10,500	350	2,250	-
• sanitary hot water	dwellings	6,000	-	10,500	1,750	2,250	-
• greenhouses	ha	-	-	-	10	-	-
• industrial uses	operations	-	-	-	1	-	-
• health bathing	operations	2	-	-	4	6	1

The Otopeni geothermal reservoir is located North to Bucharest. It is only partially delimited (about 300 km^2). The 23 drilled wells (of which only 17 potential producers or injectors) show a huge aquifer located in fissured limestone and dolomites, situated at a depth of 2,000÷3,200 m, belonging to the Moessic Platform. The geothermal water has wellhead temperatures of 58÷84°C, and a rather high TDS (1.5÷2.2 g/l), with a high H_2S content (up to 30 ppm). Therefore, reinjection is compulsory for environmental protection. The production was carried out in the Otopeni area using downhole pumps, because the water level in the wells is at 80 m below surface. The total flow rate was 22÷28 l/s. At present, only one well is in use, almost all year round, for health and recreational bathing.

3. UTILISATION OF GEOTHERMAL ENERGY

Due to economic difficulties, only one new geothermal project for bathing and swimming was completed during 2005-2009, and some existing district heating systems were developed. Many of the geothermal operations completed before 2004 continued to operate, with some exceptions where the users went broke and closed their operations (mainly greenhouses). The geothermal energy utilisation as of 31 December 2009 is shown in the Appendis, in the standard Table 3.

The total capacity of the utilised wells is about 180 MW_t, which produces annually about 1,235 TJ. The operations in Mihai Bravu, Bors and Ciumeghiu (Table 3) have been closed in the early 2000's, because the greenhouses in the area have been closed. All other operations from reservoirs with 0 l/s production have been closed during the last 5 years. These were expected to resume operation in the short or medium term future, or to start new operations, but it did not happen yet. For this reason, these locations have not been removed from Table 3, and their installed capacity has been added in column 6.

The main direct uses of geothermal heat (standard Table 5 in Appendix) are: district heating and individual space heating (56.37%), and health and recreational bathing (39.58%). In a few places geothermal energy is also used for greenhouse heating (about 10 ha), fish farming (a few farms), industrial processes, and drying. Detailed data on installed capacity and annual energy used is not available by type of utilisation. In areas where the available wellhead temperature is rather low, geothermal water is only used for health and recreational bathing (e.g. Felix spa), or for fish farming, depending on the chemical composition. In other areas, even if the temperature is higher, the geothermal water is still used only for bathing (e.g. Acas-Beltiug and Tasnad), or for fish farming (e.g. Santandrei). In other areas, with higher temperatures and in larger communities, geothermal water is first used for district heating, some industrial processes, and only a part of the heat depleted water is used for bathing (or for fish farming), the rest being reinjected, if possible (e.g. Oradea).

Ground source (geothermal) heat pumps marked practically opened in Romania only in 2000, and is now developing quite well. It is still impossible to obtain data from all companies installing ground source heat pumps, or from any Governmental institution. Wherever possible, the favoured solutions were ground water wells or horizontal heat exchangers, borehole heat exchangers becoming more and more common in the last years. Based on the available information, the installed heating capacity of the ground source heat pumps installed in Romania by the end of 2009 is estimated at about 5-6 MW_t (stated 5.5 MW_t in Table 5 for adding to the total installed capacity).

During 2005 and 2009, seven wells have been drilled, with total depth of 13.8 km (standard Table 6 in Appendix), all financed from the State Budget within the framework of the national geological exploration program. Three were exploration wells, being drilled by Foradex in areas not yet explored in the southern part of Romania, and were rather unsuccessful, having either too low flow rates or too low wellhead temperatures for energy uses (highest one 35°C, planned to be used for health and recreational bathing). Four wells were drilled by Transgex in the western part of Romania, in areas where geothermal resources have already been identified (Sacuieni, Marghita, and two in Oradea).

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 Economy (Energy Department). The total man – year effort related to geothermal of all these institutions is estimated to be about 2 each year (standard Table 7 in Appendix).

There are no public utilities actually operating geothermal systems. Geothermal district heating systems are operated only by one of the two companies mentioned before (Transgex). 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 Electrical Engineering and Information Technology, the Faculty of Medical Sciences, and the Geothermal Research Centre. Five members of its current academic staff followed the six months UNU Geothermal Training Programme in Iceland. The Faculty of Energy Engineering currently offers a B.Sc. program in Thermal Energy (oriented to renewable energy sources) and a M.Sc. program in Renewable Energies.

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. was a large state owned company privatised in September 2007. The main part of its activity is drilling for oil. gas, geothermal and industrial water (in Romania and abroad). Being acquired by a real estate investment company, it is currently being reorganised and geothermal does not seem to be a priority at present.

The 1 man – year effort in the standard Table 7 in the Appendix, column 4, should be considered as a cumulated value over 5 years for both companies (Transgex and Foradex), with the reserve of a rather gross estimate.

During 2005-2009, the investments in geothermal projects (standard Table 5 in the Appendix) totalled 9.4 million USD, less than in any 5 years interval before, but still mainly from the State Budget, for drilling (geological exploration and research). Out of the total investments in geothermal projects, the cost of drilling the four wells represents almost 80%. Even the wells drilled in known

reservoirs have been funded from the State Budget, as research needed to confirm the resource. Successful wells can be leased from the NAMR, usually by the company that drilled them. In this way, the State practically completely covers the geological risk of drilling the wells, and also contributes significantly to the capital cost of new projects or of development of existing ones.

The production equipment for some wells (line shaft pumps, variable speed drives, automation, etc) has been financed from other funds the Transgex Company could raise (own equity, bank loans, grants from the European Commission and National Funds, carbon credits, etc).During 2005-2009, the Transgex Company:

- built district heating systems in the small towns of Sacuieni and Marghita;
- built two greenhouses (1 ha each) and a district heating system in the Livada village;
- extended the district heating system in the town of Beius, using small modular substations for each large building;
- increased exploitation in Oradea in all districts where geothermal wells exist, and drilled two more wells (still not used at the time of this writing).

Transgex plans to extend in the near future some existing district heating systems (Sacuieni, Marghita, Livada, etc), to drill an injection well and to extend the district heating system in Beius, and mainly to increase the production from the Oradea reservoir to its maximum capacity. For this last plan, at the time of this writing, Transgex is reorganising its collaboration with the Municipality of Oradea, both parties agreeing to establish a joint venture with legal personality as a public - private partnership (PPP). The “association in participations” that existed before had no legal personality and did not work very well, this being the main reason that the LOW-BIN demonstration project for power generation, funded by the European Commission under the 6th Framework Program, failed in Oradea (Rosca et al., 2010), although there were no technical problems and the ORC unit has already been designed (but not manufactured).

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APPENDIX - Standard Tables

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

Locality	Type[1)]	Maximum Utilization			Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Satu Mare	HB	12	65	30	1.80	7.00	32.30	0.56
Carei	BI	5	45	30	0.30	3.00	5.90	0.62
Acas-Beltiug	B	21	68	30	3.30	0.25	1.27	0.01
Tasnad	B	10	70	25	1.88	0.17	0.99	0.02
Sacuieni	HDB	8	80	25	1.84	0.80	5.79	0.10
Marghita	HDB	12	65	25	2.01	0.27	1.44	0.02
Boghis	BH	12	45	25	1.00	0.00	0.00	0.00
Mihai Bravu	GF	6	65	25	1.00	0.00	0.00	0.00
Sannicoau de Munte	B	5	65	25	0.84	0.17	0.90	0.04
Bors	G	25	120	40	7.80	0.00	0.00	0.00
**Oradea	HDB	90	87	30	21.46	56.77	426.83	0.63
Livada	DG	10	88	30	2.43	0.21	1.61	0.02
Felix	BH	140	45	25	11.72	95.00	250.61	0.68
Madaras	BH	5	46	25	0.44	0.16	0.44	0.03
Ciumeghiu	G	12	92	35	2.90	0.00	0.00	0.00
Cighid	HB	10	72	25	1.97	0.37	2.29	0.04
Beius	HDB	90	84	30	20.33	15.48	108.22	0.17
Santandrei	F	25	79	35	4.50	2.00	9.70	0.07
Macea	HGB	12	57	30	1.35	0.75	2.65	0.07
Curtici	HGB	16	57	30	1.81	13.00	10.60	0.20
Dorobanti	GB	12	57	30	1.35	2.00	7.12	0.17
*Sofronea	HB	6	50	30	0.50	0.00	0.00	0.00
Arad	B	12	40	25	0.80	7.00	13.80	0.54
Nadlac	IDBG	10	75	35	1.67	5.00	26.40	0.50
Sannicolau	IDBG	15	78	35	2.70	3.00	17.00	0.20
Saravale	HB	8	75	35	1.34	0.00	0.00	0.00
Tomnatic	GB	45	78	35	8.09	0.00	0.00	0.00
Lovrin	DGB	8	78	35	1.44	2.00	11.34	0.25
*Periam	HB	10	70	35	1.46	0.00	0.00	0.00
Jimbolia	IDBG	8	78	35	1.44	1.00	5.67	0.12
*Teremia	GHB	10	80	35	1.88	0.00	0.00	0.00
*Lenauheim	HBG	8	80	35	1.50	0.00	0.00	0.00
*Comlosu Mare	HB	5	70	35	0.73	0.00	0.00	0.00
*Grabat	GB	10	80	35	1.88	0.00	0.00	0.00
*Beregsau	GB	6	72	35	0.93	0.00	0.00	0.00
Timisoara	DB	10	50	35	0.63	1.00	1.98	0.10
Herculane	B	75	52	25	8.50	50.00	148.00	0.55
Olt Valley	DB	45	92	35	10.73	19.00	142.82	0.43
North Bucharest	HB	242	75	35	40.50	2.00	0.06	0.00
TOTAL		1,071.00			178.75	287.40	1,235.73	0.22

*) wells above 50°C wellhead temperature, without Exploration Permit (NAMR Licence), in stand-by;
**) maximum annual average flowrate approved by the NAMR Licence.

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2009

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]	13.28	164.83	0.39
District Heating [4)]	58.95	531.72	0.29
Greenhouse Heating	4.18	20.78	0.16
Fish Farming	4.50	9.70	0.07
Agricultural Drying[5)]	1.40	12.70	0.29
Industrial Process Heat[6)]	0.75	6.84	0.29
Bathing and Swimming[7)]	64.68	489.16	0.24
Subtotal	147.74	1,235.73	0.22
Geothermal Heat Pumps	5.5	?	?
TOTAL	153.24		

[4)] Other than heat pumps
[5)] Includes drying or dehydration of grains, fruits and vegetables
[6)] Excludes agricultural drying and dehydration
[7)] Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2009 (excluding heat pump wells)

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration	(all)	-	3	-	-	4.2
Production	>150°C	-	-	-	-	
	150-100°C					
	<100°C	-	4	-	-	9.6
Injection	(all)	-	-	-	-	
Total		-	7	-	-	13.8

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

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	2	3	12	-	1	27
2006	2	3	12	-	-	27
2007	2	3	12	1	-	27
2008	2	3	12	-	-	25
2009	2	3	12	-	-	24
Total	10	15	60	1	1	132

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) 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$	%	%
1995-1999	9	11	7	-	-	100
2000-2004	4.4	3.6	4.5	-	56	44
2005-2009	2.7	4.6	2.1	-	14	86