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Geothermal Energy Use, Country Update for Romania

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ABSTRACT

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 MWt (for a reference temperature of 25°C). Of this total, only about 180 MWt 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 2012, the annual energy utilisation from these wells was about 360 GWh. 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 2007-2012, six geothermal wells have been drilled in Romania with National financing. Some of these wells, drilled to depths ranging from 1,700 m to 2,500 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.

The first shallow geothermal applications were implemented in Romania in the late 1990s. At the beginning, they were based on open system technology and used reversible ground-source heat pumps.

Today, the most complex and largest application in progress and state of the art for Europe is ELI-NP Extreme Light Infrastructure that is to be built in Bucharest-Magurele. ELI-NP is the first pan-European research facility built in Eastern Europe which oriented on high-level research on ultra-high intensity laser. The heating and cooling system is in the range of 5,4 MW, obtained by a borehole heat exchanger with 1080 boreholes at 120 m depth under a field of around 27000 m². The total investment cost of about 356 million € is paid mainly from Romania's allocation of EU structural funds.

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 licensed 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 energy produced from renewable energy sources, geothermal included. For 1 MWh electric energy produced from geothermal energy the producer receives now 2 green certificates. One additional green certificate is awarded for co-generation systems. Unfortunately, the National Agency for Energy Regulation does not award, yet, any green certificates for geothermal power claiming that there are too few producers and not enough information to notify the European Commission. 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 2012, 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.

In the shallow geothermal domain the market outruns the national regulation framework for GHP applications. The Law No. 372/2005 on the Energy Performance of Buildings that transposed the EPBD into the national legislation entered is applicable since January 1, 2007. It contains a mandatory request regarding the presence of heat pumps as an alternative in the feasibility study for new buildings larger than 1.000 m^2. In fact, this provision is not yet applicable, because the responsible with awarding construction licenses, the local authorities, lack the knowledge and the management structure for analyzing this kind of feasibility studies.

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 economic and technical operation and development of the energy sector (electric and thermal) is regulated, ruled, supervised and monitored by the National Agency for Energy Regulation (NAE)R, 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, the National Power Transport Company (TRANSELECTRICA) has to purchase the entire available power produced from renewable resources at the price established by the NAER, based on the financial and economic assessment study. The competent authority for the Energy Efficiency Law was the National Agency for Energy Conservation (NAEC) which was included in NAER.

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, Tasnad, Sinicolau de Munte, Santion. Geothermal energy is delivered in towns to block of flats, administrative institutions and economic agents, and in smaller communities to block of flats and administrative buildings, mainly in open loops.

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.

For shallow geothermal energy exploitation, by means of ground source heat pumps, there are many companies that install this kind of heating systems. The largest company installing ground source heat pumps is ASA Holding located in Bucharest.

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 and Industrial Management, the Faculty of Environment Protection, the Faculty of Electrical Engineering and Information Technology, and the Faculty of Medicine and Pharmacy. The Department of Energy Engineering currently offers B.Sc. training in Engineering of renewable energy systems and M.Sc. training in Renewable Energies.

The Romanian Geoexchange Society is a non-profit organization established in 2002, whose objectives are to promote the HVAC GSHP systems, to create a national regulatory frame, to educate the users and to direct them to RES, to represent the Romanian market abroad and to present its achievements, to train the Romanian specialists, to contribute at the European training and certification frame for the 22 specialties involved in the domain of heating and cooling with geothermal heat pump (according IGSHPA) and to bring the Romanian technical and managerial experience into the European projects.

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 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 2012, the average flow rate was about 280 l/s, the annual energy utilisation for direct use was about 360 GWh, with an average capacity 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, six geothermal wells have been drilled to depths ranging from 1,700 m to 2,500m, of which one was unsuccessful (dry and cold), and three are producing geothermal water with wellhead temperatures of between 70°C and 90°C.

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 Neocene 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 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, for heating system of many individual houses in open loop, swimming pool, 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.

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 Moesian 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.

The Romanian strategic documents - National Strategy of Energy, RES Strategy and NREAP - do not specifically take into consideration the ***shallow*** geothermal energy and its potential. Currently, the figures that quantify the geothermal energy in all these documents refer to ***deep*** geothermal energy only. The geothermal maps present the location of deep geothermal reservoirs, without any concern about the shallow geothermal energy which is considered to be accessible everywhere in the country. The GEOTRAINET project documents (2008-2011 www.geotrainet.eu) include a map of Europe in which the underground temperatures at more than 12-15 m in Romania in the present times are between 12 – 16°C. These values were stated by the GSHP specialists that monitored the temperatures acquired in the implemented applications and test drills.

3. UTILISATION OF GEOTHERMAL ENERGY

Due to economic difficulties, only a few new geothermal projects were completed during 2007-2012. By far, the most interesting project is a binary cycle ORC geothermal power plant. In spite of its small installed capacity (Tables A and B in Appendix) it represents the first step in this direction (of producing electricity from geothermal water) after many years. Other new projects are a district heating in open loops, and one geothermal project for bathing and swimming. Also, some existing district heating systems were developed. Many of the geothermal operations completed before 2007 continued to operate, with some exceptions where the users went broke and closed their operations (mainly greenhouses).

All 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.

The main direct uses of geothermal heat are (Table C): district heating and individual space heating, and health and recreational bathing. 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 (Table D), some industrial processes, and only a part of the heat depleted water is used for bathing (or for fish farming), the rest being reinjected.

The market for ground source heat pumps GSHP practically opened in Romania only in the late 1990' and is now developing quite well. Because nowadays there are no technical norms for GSHP applications, it is still impossible to obtain data from all companies installing such systems. They are systematically avoiding openly present their applications as references. On the other hand, there are not central or local authorities, Governmental institutions or Agencies, specially appointed to keep the evidence (traceability), to certify, to authorize and to monitor the performance of the applications, and this is another reason for the lack of reliable data.

Table 1: Large GSHP systems with borehole heat exchangers (BHE) longer than 10000 m

City, Name	No. of BHE	Depth BHE [m]	Total BHE [m]
Magurele – Bucharest, ELI-NP (under constr.)	1080	125	135000
Valul lui Traian, Cardinal Motors (2009)	357	70	24990
Snagov, Vila 23 Hotel (2008)	224	70	15680
Focsani, ARTIFEX (2012)	120	125	15000
Bucharest, Midocar Est (2008)	144	75	10800
Bucharest, Green City Hall (under constr.)	80	125	10000

At the beginning, in the first 7-8 years after 1990, the favoured solutions in GSHP applications were ground water wells and rarely horizontal heat exchangers. These technologies were suitable for small applications and for specific geographic and climatic areas in the country. In the last years, the larger applications required larger water flows that are not accessible in all potential locations. This is why the borehole heat exchangers became more and more common especially for commercial buildings. Table 1 presents the total length of largest GSHP systems built in Romania.

A lot of foreign investors or dealers of products manufactured abroad “imported” in Romania the GSHP technology from the manufacturers' country (Germany, Austria etc.). Nowadays the total price for drilling, “U” pipe mounting and cementing the geothermal heat exchanger is in the range 15-35 Euro/m and depends of the depth, the diameter, the number of drillings, the soil type and drilling technology, the accessibility in the site etc. The drilling for both open and closed systems is not specifically regulated by the authorities but is considered as any regular water supply drilling. For closed-loop systems the current drilling depth is 70 ÷ 120 m.

One well was drilled by Foradex, as exploration well, in an area not yet explored in the southern part of Romania, and was rather unsuccessful, having too low flow rate and too low wellhead temperatures for energy uses. Five wells were drilled by Transgex in the western part of Romania, in areas where geothermal resources have already been identified (Diosig, Tasnad, Beius, and two in Oradea).

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 only Governmental project involving shallow geothermal energy was initiated in 2006 by a Government decision and was targeted to 10 rural schools. The chosen solution was “open loop technology” (in order to use the existing water supply well and to drill only the reinjection well), but the “standard” project was not suitable for all the 10 locations. For this reason, nowadays only 5 from 10 of applications are still functional. None of these are monitored for metering the performance and quantity of renewable energy extracted. All these applications were for heating-only purposes (in summer time, the schools are not open for recreational activities especially in rural areas). The total allocated amount was under 1 million Euro, equally shared between the 10 projects, and it included the cost of indoor distribution sub-systems, too.

Based on the little available information, the heating capacity of the ground source heat pumps installed in Romania by the end of 2012 is estimated at about 20 MWt.

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.

During 2007-2012, the investment and employment in geothermal projects totalled about 10 million EUR, 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 six 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 2007-2012, the Transgex Company:

- installed the first power generation unit that produces electricity from geothermal water in Romania;
- built district heating systems in the small towns of Tasnad and Livada;
- extended the district heating systems in the small towns of Sacuieni and Marghita;
- 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.

Transgex plans to extend its electricity production up to 1.2 MWe and also, in the near future, to develop some existing district heating systems (Sacuieni, Tasnad, Livada, etc), 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, together with the Municipality of Oradea, is developing a geothermal district heating project in Nufarul neighbourhood of heat pump assisted type.

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Tables A-G

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2012	0.05	0.4	7069	61931	0.000707	0.000645
Under construction end of 2012	0	0	--	--	--	--
Total projected by 2015	1.2	10	--	--	--	--

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commiss.	No of units	Status	Type	Total inst. Capacity (MW_e)	Total run-ning cap. (MW_e)	2012 product. (GWh_e/y)
Oradea	CE Iosia Nord	nov.2012	1	O	B-ORC	0.05	0.05	0.025
total			**1**			**0.05**	**0.05**	**0.025**

Key for status:		Key for type:			
O	Operating	D	Dry Steam	B-ORC	Binary (ORC)
N	Not operating (temporarily)	1F	Single Flash	B-Kal	Binary (Kalina)
R	Retired	2F	Double Flash	O	Other

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

	Geothermal DH Plants		Geothermal heat in agriculture and industry		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2012	158	300	8	50	10	12
Under construction end of 2012	2	5.2	--	--	--	--
Total projected by 2015	190	380	--	--	--	--

Table D: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Oradea	Iosia Nord	2005	NO	NO	19	24.2	25	78.5
Oradea	Nufarul	1992	NO	NO	5	5	10	100
Oradea	Calea Aradului	2002	NO	NO	1.6	1.6	3.9	100
Beius	Beius	2001	NO	NO	21	21	25.6	100
Sannicolau	Sannicolau	1980's	NO	NO	2.7	2.7	3.3	100
Saravale	Saravale	1980's	NO	NO	1.34	1.34	2.21	100
Lovrin	Lovrin	1980's	NO	NO	1.44	1.44	2.16	100
Jimbolia	Jimbolia	1980's	NO	NO	1.44	1.44	2.85	100
Teremia	Teremia	1980's	NO	NO	1.88	1.88	3.45	100
Calimanesti	Calimanesti	1980's	NO	NO	10.73	10.73	18.7	100
Otopeni	Otopeni	1980's	NO	NO	10.6	10.6	17.67	100
Moara Vlasiei	Moara Vlasiei	1980's	NO	NO	29.9	29.9	33.5	100
total					**106.63**	**111.83**	**148.34**	

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012	400*	20*	32*	20*	1*	N/A
Projected by 2015	300	15	100			

* - Estimate

Table F: Investment and Employment in geothermal energy

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power	0.2	3	5	30
Geothermal direct uses	0.6	8	15.5	230
Shallow geothermal	1.0*	20	5.0**	50**
total	**1.8**	**31**	**25.5**	**310**

* - Estimate

** - Without **ELI-NP** - Extreme Light Infrastructure - Nuclear Physics. Only ELI-NP will require minimum 250 specialized heat pump installers and geothermal ground heat exchanger installers.

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	National Research Plan II, by competition	National Research Plan II, by competition	National Research Plan II, by competition
Financial Incentives – Investment	N/A	Grants from Environment Fund	DIS - "Green House" Program (approx. 1350 Eur/application)
Financial Incentives – Operation/Production	Green Certificates (not operational, yet)	N/A	N/A
Information activities – promotion for the public	Media information (not on regular basis)	Media information (not on regular basis)	N/A
Information activities – geological information	No	No	No
Education/Training – Academic	YES, BSc, MSc and PhD in Renewable Energies at the University of Oradea	YES, BSc, MSc and PhD in Renewable Energies at the University of Oradea	Basics in all construction and polytechnic universities in the country. Doctoral studies in some of them (UPB, TUCEB and UOR).
Education/Training – Vocational	NO	NO	The 2 involved specialties (GSHP installers and GHE installers) are in course of official recognition and inclusion in National Occupations File (COR). The occupational standards are also in course of elaboration. The specialization courses are not recognized and endorsed by the Education Ministry if the respective specializations are not included in COR.

Key for financial incentives:					
DIS	Direct investment support	RC	Risc coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota