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# CURRENT STATUS OF GEOTHERMAL DEVELOPMENT IN ROMANIA

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## ABSTRACT

Exploration for geothermal resources began in Romania in the early 1960's. Over 250 wells, drilled to depths between 800 and 3,500 m, 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 available heat 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 or in fractured carbonate formations. 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 45-120°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 2005-2007 Foradex drilled 3 wells, 2 of them in E and SE-Bucharest, and one in Covasna County.

## 1. INTRODUCTION

Romania 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. Practical accomplishments of the last ten years are rather modest: Beius, Cighid, Oradea and Calimanesti-extension. 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.

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 more than would have been expected the development of geothermal resources, given the demonstrated substantial resources and 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 instead of pumping mode) and the lack of reinjection into the reservoir of the heat depleted geothermal water. Some systems, on a limited basis though, are or were applying the doublet concept of heat mining (Oradea, Bors and until 1994 Otopeni – all fissured carbonate reservoirs). Relatively low cost reinjection in sandstone reservoirs will become critical for the disposal of the waste geothermal water in many locations, due to new environment protection regulations.

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 2003. 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 doubling the share of renewables from 6% at present to 12% in 2010. These targets are also assumed by Romania, as a member of the European Union from 2007.

At present, except for small hydro, all other renewable energy sources have minor contributions to the Romanian energy mix. The main energy sources are still fossil fuels.

Two companies are currently involved in geothermal operations. Foradex S.A., located in Bucharest, a state owned drilling company (privatised in Sept. 2007) that has both exploration and exploitation concessions for the geothermal reservoirs located in the Southern half of Romania (Banat county, Olt Valley - Valcea County and North Bucharest). Transgex S.A., located in Oradea, is also mainly a drilling company privatised in 2000, and has exploration and exploitation concessions for the geothermal reservoirs located in the Western part of Romania (mainly Bihor County).

The University of Oradea has the Geothermal Research Centre, the International Geothermal Training Centre and its Faculty of Energy Engineering offers undergraduate and graduate studies in renewable energies, including geothermal. A consulting company, Geofluid S.A., which is a French-Romanian joint venture, operates in Oradea too.

## 2. GEOTHERMAL RESOURCES

The search for geothermal resources to be used for energy purposes began in the early 60's, based on a detailed geological programme for hydrocarbon resources. There are over 250 wells drilled with depths between 800 and 3,500 m, that show the presence of low-enthalpy geothermal resources (50-120°C), which enabled the identification of 9 geothermal areas, 7 in the western part and 3 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 25°C). Of this total only 145 $MW_t$ are currently used, from 96 wells (of which 35 wells are used for balneology and bathing) that are producing hot water in temperature range of 45-115°C. For 1999, the annual energy utilisation from these wells was about 2,900 TJ, from which health and recreational bathing was 870 TJ, with a capacity factor of 0.62.

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 (wood and grain drying, milk pasteurisation, flax processing) 8.7%; fish farming and animal husbandry 2.3%". More than 80 % of the wells are artesian producers, 18 of them require anti-scaling chemical treatment, and 6 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 range of 35-65°C. The geothermal water is also used in 24 outdoor and 7 indoor pools.

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. The main geothermal reservoirs in Romania are located in Oradea, Bors, Beius, Ciumeghiu, Olt Valley and Otopeni (Figure 1).


FIGURE 1: Location of the main Romanian geothermal reservoirs

## 3. UTILISATION OF GEOTHERMAL ENERGY

Most of the geothermal operations completed before 1999 are still in operations, 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 2007 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 2007
(flowing wells with Contract or stand-by wells – all having more than 50°C)

| Locality | Type | Capacity or actual max. possible use | | | Capacity (actual use year around) | | Annual utilisation | |
|---|---|---|---|---|---|---|---|---|
| | | Flow rate | Temperature (°C) | | Power | Ave. flow | Energy | Capacity |
| | | (kg/s) | Inlet | Outlet | (MWt/ hour) | (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 |
| Santandrei, BH | FHGB | 25 | 79 | 35 | 4.5 | 2 | 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 | 10.6 | 0.20 |
| Dorobanti | GB | 12 | 57 | 30 | 1.35 | 2 | 7.12 | 0.17 |
| *Sofronea | HB | 6 | 50 | 30 | 0.50 | 0 | 0 | 0 |
| **Arad | B | 12 | 40 | 25 | 0.8 | 7 | 13.8 | 0.54 |
| Nadlac | IHBG | 10 | 75 | 35 | 1.67 | 5 | 26.40 | 0.50 |
| Sannicolau | IHBG | 15 | 78 | 35 | 2.70 | 3 | 17.00 | 0.20 |
| Saravale | HB | 8 | 75 | 35 | 1.34 | 0 | 0 | 0 |
| Tomnatic | GB | 45 | 78 | 35 | 8.09 | 0 | 0 | 0 |
| Lovrin | HGB | 8 | 78 | 35 | 1.44 | 2 | 11.34 | 0.25 |
| *Periam | HB | 10 | 70 | 35 | 1.46 | 0 | 0 | 0 |
| Jimbolia | IHBG | 8 | 78 | 35 | 1.44 | 1 | 5.67 | 0.12 |
| *Teremia | GHB | 10 | 80 | 35 | 1.88 | 0 | 0 | 0 |
| *Lenauheim | HBG | 8 | 80 | 35 | 1.50 | 0 | 0 | 0 |
| *Comlosu Mare | HB | 5 | 70 | 35 | 0.73 | 0 | 0 | 0 |
| *Grabat | GB | 10 | 80 | 35 | 1.88 | 0 | 0 | 0 |
| *Beregsau | GB | 6 | 72 | 35 | 0.93 | 0 | 0 | 0 |
| Timisoara | HB | 10 | 50 | 35 | 0.63 | 1 | 1.98 | 0.10 |
| ***Herculane | B | 75 | 52 | 25 | 8.5 | 50 | 148.0 | 0.55 |
| Olt Valley | HB | 45 | 92 | 35 | 10.73 | 19 | 142.82 | 0.43 |
| North Bucharest | HB | 242 | 75 | 35 | 40.50 | (2) | (0.06) | (0) |
| **TOTAL** | | 889 | | | 156.6 | 659 | 2840.8 (235) | |

* Well(s) over 50°C, without Exploration Permit (NAMR Licence), in stand-by;
** Well(s) under 50°C, considered as without energetic value;
*** Foradex does not consider Herculane as a geothermal field!

Explanation: H = Space heating & district heating (exc. 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 a short- or medium-term future. The greenhouses in Bors have been purchased by a private company and operation is expected to start. 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 $MW_t$. By type of utilisation, the actual situation in Romania is shown in Table 3.

TABLE 3: Summary table of geothermal direct heat uses

| Use | Installed capacity (MWt) | Annual energy use (TJ/yr) | Capacity factor |
|---|---|---|---|
| Space heating | 57.2 | 1129 | 0.62 |
| Air conditioning (cooling) | | | |
| Greenhouse heating | 28.3 | 486 | 0.54 |
| Fish and animal farming | 3.1 | 65 | 0.66 |
| Agricultural drying | | | |
| Industrial process heat | 14.1 | 246 | 0.55 |
| Snow melting | | | |
| Bathing and swimming | 42.2 | 915 | 0.68 |
| Other uses (specify) | | | |
| **Subtotal** | 144.9 | 2841 | 0.62 |
| Geothermal heat pumps | 4 | - | - |
| **TOTAL** | 148.9 | 2841 | 0.62 |

During 1999-2007, 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 programme. 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 geothermal resources were already identified (Beius and Olt Valley).

TABLE 4: Wells drilled for electrical, direct and combined use of geothermal resources from January 1, 1999 to December 31, 2007

| Purpose | Wellhead temperature | Number of wells drilled | | | | Total depth (km) |
|---|---|---|---|---|---|---|
| | | Electric power | Direct Use | Combined | Other (specify) | |
| Exploration | (all) | - | 6 | - | - | 12.2 |
| Production | >150° C | - | - | - | - | - |
| | 150-100° C | - | - | - | - | - |
| | <100° C | - | 2 | - | - | 3.7 |
| Injection | (all) | - | - | - | - | - |
| **Total** | | **-** | **8** | **-** | **-** | **15.9** |

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 geothermal energy is available 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).

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). There are no public utilities actually operating geothermal systems.

Geothermal district heating systems are operated only by one of the two companies mentioned before. 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 from 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 geothermally 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 at Transgex S.A. increased slowly after 2000, when the company was privatised, with geothermal currently being its main business. In the last five years the company also paid foreign experts for consulting, whenever needed.

Foradex S.A. is a large company (state owned until September 2007). The main part of its activity is drilling for oil & gas, geothermal and industrial water (in Romania and abroad). It has a geothermal department in Bucharest and three on-site teams (Olt Valley-Calimanesti-Valcea County, Timisoara-Timis Couny and Oradea-Bihor County). The project in Calimanesti for combustible gas separation was co-funded by the EC, and foreign consultants have also been partners in the project.

During 1999-2004, the investments in geothermal projects (Table 5) totalled 12.5 million USD, less than half as compared to 1990-1994 and 1985-1989, when all projects were financed from public funds (mainly from the State Budget, geological exploration and research).

TABLE 5: Total investments in geothermal

| Period | Research & development, incl. Surface exploration & exploration drilling (Million US$) | Field development, incl. production drilling & surface equipment (Million US$) | 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 seven 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 need 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 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 kilometres 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 of the 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 also to 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 2 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 gases (7 $Nm^3/m^3$, of which 75% is $CO_2$). The currently artesian production (10 l/s/well) could be increased to 30 l/s/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 town* 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, one 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 of about 5,000 m.

There is a good chance for receiving funding for this research from the Government. In case the deep wells will be drilled and the well head temperature will be high enough, the Transgex Company intends to develop these two fields for power generation (ORC power plants), the current Romanian legislation now quite favourable for private power generation, mainly from renewable energy sources.

### 4.2 Foradex S.A.

*The Olt Valley area:*

- Upgrading the geothermal district heating and sanitary hot water with a peak load boiler in Calimanesti town; pilot co-generation plant using separated methane from geothermal water (power co-generation);
- Re-start drilling of well 1010 Seaca, below 3,200 m, to achieve both increased flow and temperature; pipe connection with Calimanesti DH;
- Possible new geothermal deep well for Oltenia Fair Trade, South Calimanesti (Valcea County);

*The Banat area (SW-Romania):*

- Line shaft pump to increase production, rehabilitation and extension of the DH as geothermal based network (with natural gas fired peak load boilers) in the Sannicolaul Mare city; well cleaning & restart geothermal production for Zoppas Industries – Sannicolaul Mare (GEF supported project);
- Lovrin DH upgrade (GEF supported project).

*The Bucharest area:*

- Geothermal DH (with natural gas/fuel oil fired peak load boilers) and water recreation complex (aquapark) in Snagov spa, Ilfov County;
- Geothermal water wellness centres in N-Bucharest (Cozieni, Ilfov County and Bucharest House of Press);
- Space heating, sanitary water, air conditioning (AC) and balneology-spa water for a hospital in Balotesti village, Ilfov County;
- Geothermal heat pump (HP) floor heating and AC for a 15 floors office building.

*The Santandrei, Bihor County, area:*

- Geothermal DH for the local community, water recreation complex, sports field; possibly geothermal water supply for Oradea City.

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