# GEOTHERMAL DEVELOPMENT IN ROMANIA

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## ABSTRACT

The exploration for geothermal resources began, in Romania, in the early 60's based on a detailed geological exploration program for hydrocarbon resources that had extensive budgets, which also enabled the identification of eight geothermal areas. There are over 200 wells drilled with depths between 800-3,500 m, which show the presence of low enthalpy geothermal resources (40-120°C). The completion and experimental exploitation of over 100 wells, in the past 25 years, enabled the evaluation of the exploitable heat resources from geothermal reservoirs. The proven reserves, with the already drilled wells, amount at about 200,000 TJ for 20 years.

The main geothermal systems discovered on the Romanian territory are found in porous permeable formations such as sandstones and siltstones (Western Plain and the Olt Valley) or in fractured carbonate formations (Oradea, Bors, North Bucharest). The total thermal capacity of the existing wells is about 480 $MW_t$ (for a reference temperature of 25°C). Out of this, only 152 $MW_t$ are currently used, from 96 wells (of which 35 wells are used for health and recreational bathing) that are producing hot water in the temperature range of 45-115°C. For 2002, the annual energy utilisation from these wells was about 2,900 TJ, with a capacity factor of 0.6. More than 80% of the wells are artesian producers, 18 wells require anti-scaling chemical treatment and 6 are reinjection wells.

During 1995-2002, 15 exploration-production geothermal wells were drilled and completed (of which two dry holes), financed by the geological exploration fund of the State's Budget, with depths varying between 1,500-3,500 m.

The development of direct utilisation of geothermal resources is very much slowed down by the difficulties encountered during the transition period from centrally planned to free market economy; the present geothermal production status stands far below the expectation allowed by the assessed potential, the geothermal operations lagging behind in technology. The main obstacle for the geothermal development in Romania is the scarcity of the domestic investment capital. In order to stimulate the interest of potential investors from developed countries and to comply with the requirements of the large international banks, an adequate legal and institutional framework has been created, adapted to a market oriented economy.

## GEOTHERMAL RESOURCES DEVELOPMENT EXPERIENCE IN ROMANIA

### Background

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

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

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

The utilisation of these energy resources has been delayed due to the high investment costs and the very low price of the hydrocarbons. At present, at the current international market prices of fossil fuels, and the dramatic decrease of the domestic oil and gas production, the geothermal development has favourable conditions.

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

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

The present geothermal production status stands far below the expectations allowed by the locally assessed potential because of non sustained production (self flowing mode instead of artificial lift) and the lack of injection into the source reservoir of the heat depleted brine (no resource conservation nor reservoir pressure maintenance). Some systems operated, on a limited basis though, are applying the doublet concept (i.e. combining a production/injection well pair) of heat mining (Oradea, Bors, Otopeni). These first projects have enabled to build up a nucleus of expertise in modern reservoir exploitation management techniques.

The difficulties encountered at the injection into sandstone reservoirs (mostly in the Pannonian Basin) cause environmental problems (requiring higher costs to solve), as well as the decline of the reservoir pressure. Because of the restriction imposed by the legislation regarding environmental protection most of the proven resources would not be exploited if the problem of reinjection will not be solved. The technology of reinjection is, at present, one of the most important tasks for research in geothermal energy production.

**Geothermal resources**

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

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

The search for geothermal resources for energy purposes began in the early 60's, based on a detailed geological program for hydrocarbon resources (that had extensive budgets). There are over 200 wells drilled with depths between 800 and 3,500 m, that shows the presence of low enthalpy geothermal resources (40÷120°C), which enabled the identification of 8 geothermal areas, 6 in the Western part and 2 in the Southern part. The completion and experimental exploitation (as part of geological investigations) of over 100 wells in the past 25 years made possible the evaluation of exploitable heat from geothermal reservoirs. The proven reserves, with the already drilled wells, are estimated at about 200 PJ for the next 20 years. The total installed capacity of the existing wells is about 480 $MW_t$ (for a reference temperature of 30°C). Out of this only 140 $MW_t$ is currently used, from 65 wells that are producing hot water in temperature range of 55÷115°C (Cohut & Bendea, 1997).

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

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

During the last 10 years, 26 exploration - production geothermal wells were drilled, completed and tested (of which only two dry holes), financed from the geological exploration fund of the State Budget, with depths varying between 1,500 and 3,500 m, and 9 of them are used for district heating. Three new geothermal wells are currently in drilling.

**The geothermal systems** discovered on the Romanian territory are located in porous permeable formations such as sandstones and Pannonian siltstones, interbedded with clays and shales specific for the Western Plain and Senonian specific for the Olt Valley or 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 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 2,100 m. It was investigated by 80 geothermal wells, all possible producers, out of which 37 are currently exploited. The thermal gradient is 45÷55°C/km. The surface water temperature varies between 50 and 85°C. The mineralisation 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. The wells are produced mainly artesian, but also with downhole pumps.

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

The Oradea geothermal reservoir is located in the Triassic limestone 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, and the mineralisation is lower than 0.9÷1.2 g/l. The water is of calcium-sulphate-bicarbonate type. Both aquifers, the Triassic aquifer Oradea and the Cretaceous

aquifer Felix Spa, are hydrodynamically connected and are part of the active natural flow of water. The water is about 20,000 years old and the recharge area is in the Northern edge of the Padurea Craiului Mountains and the Borod Basin. Although there is a significant recharge of the geothermal system, the exploitation with a total flow rate of 300 l/s generates pressure draw down in the system that is prevented by reinjection. Reinjection is the result of successful completion and beginning operation of the first doublet in the Nufarul district in Oradea city, in October 1992 (Lund, 1997). The Felix Spa reservoir is currently exploited by six wells, with depths between 50 and 450 m. The total flow rate available from these wells is 210 l/s. The geothermal water has a well head temperatures of 36÷48°C and is potable. The annual utilisation of geothermal energy in Oradea is 415TJ representing 15% of the total geothermal heat produced in Romania.

The Bors geothermal reservoir is situated about 6 km north-west to Oradea. This reservoir is completely different from the Oradea reservoir, although both are located in fissured carbonate formations. The Bors reservoir is a tectonically closed aquifer, with a small surface area of 12 $km^2$. The geothermal water has 13 g/l TDS, 5 $Nm^3/m^3$ GWR and a high scaling potential. 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 can only be maintained by reinjecting the whole amount of extracted geothermal water. At present, three wells are used to produce a total flow rate of 50 l/s, and two other wells are used for reinjection, at a pressure that does not exceed 6 bar. The geothermal water is used for heating 12ha of greenhouses. The dissolved gasses are partially separated at 7 bar, which is the operating pressure, and then the fluid is passed through heat exchangers before being reinjected. The Romanian PONILIT anti-scaling solution is injected at the 450 m depth, using an electric driven metering pump. The installed power is 15 $MW_t$, and the annual energy savings is 3,000 toe.

The Ciumeghiu geothermal reservoir is also located in the Western Plain, 50 km South to Oradea. Geothermal water is produced by artesian flow with a well head temperature of 105°C and 5-6 g/l TDS, with strong carbonate scaling prevented by chemical inhibition at the depth of 400 m. The aquifer is located in Lower Pannonian age gritstones, 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 is currently in use, with a capacity of 5 $MW_t$ (1 $MW_t$ from gasses).

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

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

*Table 1: The main parameters of the Romanian geothermal systems.*

| Parameter | U/M | Oradea | Bors | Western Plain | Olt Valley | North Bucharest |
|---|---|---|---|---|---|---|
| Type of reservoir | | fissured carbonate | fissured carbonate | sandstone | gritstone | carbonate |
| Area | $km^2$ | 75 | 12 | 2,500 | 28 | 300 |
| Depth | km | 2.2÷3.2 | 2.4÷2.8 | 0.8÷2.1 | 2.1÷2.4 | 1.9÷2.6 |
| Drilled wells | (total) | 14 | 6 | 88 | 3 | 11 |
| Active wells | | 12 | 5 | 37 | 2 | 5 |
| Well head temperature | °C | 70÷105 | 115 | 50÷85 | 92÷96 | 58÷75 |
| Temperature gradient | °C/100 | 3.5÷4.3 | 4.5÷5.0 | 3.8÷5.0 | 4.6÷4.8 | 2.8÷3.4 |
| TDS | g/l | 0.8÷1.4 | 12÷14 | 2÷7 | 13 | 2.2 |
| GWR | $Nm^3/m^3$ | 0.05 | 5÷6.5 | 0.5÷2.5 | 2÷2.8 | 0.1 |
| Type of production | | Artesian | Artesian | Artesian Pumping | Artesian | Pumping |
| Flow rate | l/s | 4÷20 | 10÷15 | 4÷18 | 12÷25 | 22÷28 |
| Operations | | 11 | 2 | 37 | 2 | 2 |
| Annual savings | toe | 9,700 | 3,200 | 18,500 | 2,600 | 1,900 |
| Total installed power (with existing wells) | $MW_t$ | 58 | 25 | 210 | 18 | 32 |
| Exploitable reserves (for 20 years) | MW/day | 570 | 110 | 4,700 | 190 | 310 |
| Main uses: | | | | | | |
| • space heating | dwellings | 2,000 | - | 2460 | 600 | 1,900 |
| • sanitary hot water | dwellings | 6,000 | - | 2,200 | 600 | 1,900 |
| • greenhouses | ha | 1.8 | 6 | 34 | - | - |
| • industrial uses | operations | 6 | - | 7 | - | - |
| • health bathing | operations | 5 | - | 8 | 3 | 2 |

**Wells drilled for direct use of geothermal resources**

During 1995-1999 were drilled 14 wells with total depth of 33.2 km (Table 2), financed from the State Budget, within the framework of the national geological exploration program. Five wells were exploration wells, being drilled in areas not yet explored, and eight wells were drilled in areas where already geothermal resources were identified.

Out of the 14 wells only one was a dry hole, low flowrate, high mineralisation: 32 g/l, low temperature 65ºC, and dynamic water level below 200 m of the ground. All the other wells had flowrates and temperatures of energetic interest, at present, being carried out the feasibility studies of direct use projects on these wells.

*Table 2: Wells drilled for electrical, direct and combined use of geothermal resources from January 1, 1995 to December 31, 2002*

| Purpose | Wellhead Temperature | Number of Wells Drilled | | | | Total Depth (km) |
|---|---|---|---|---|---|---|
| | | Electric Power | Direct Use | Combined | Other (specify) | |
| Exploration[1)] | (all) | | 7 | | | 16.8 |
| Production | >150° C | | | | | |
| | 150-100° C | | 8 | | | 18.4 |
| | <100° C | | | | | |
| Injection | (all) | | | | | |
| Total | | | 15 | | | 33.2 |

*Table 3: Utilisation of geothermal energy for direct heat as of 31 December 2002*

| Locality | Type[1)] | Maximum Utilisation | | | Capacity[3)] | | Annual Utilisation | |
|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (kg/s) | Temperature (°C) | | | Ave. Flow (kg/s) | Energy[4)] (TJ/yr) | Capacity Factor[5)] |
| | | | Inlet | Outlet | (MWt) | | | |
| Satu Mare | HB | 12 | 65 | 30 | 1.8 | 7 | 32.3 | 0.58 |
| Carei | BI | 5 | 45 | 30 | 0.3 | 3 | 5.9 | 0.60 |
| Acas | GB | 15 | 65 | 30 | 2.2 | 8 | 36.9 | 0.53 |
| Tasnad | HBG | 10 | 70 | 25 | 1.9 | 7 | 41.5 | 0.70 |
| Beltiug | B | 6 | 75 | 30 | 1.1 | 4 | 23.7 | 0.67 |
| Sacuieni | HBGFI | 22 | 80 | 25 | 5.1 | 12 | 87.1 | 0.55 |
| Marghita | HB | 12 | 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 | 3 | 15.8 | 0.50 |
| Bors | G | 25 | 115 | 40 | 7.8 | 12 | 118.7 | 0.48 |
| Oradea | IHGBF | 85 | 83 | 30 | 18.8 | 65 | 415.0 | 0.69 |
| Livada | HBF | 10 | 88 | 35 | 2.2 | 5 | 35.0 | 0.50 |
| Felix | BH | 140 | 45 | 25 | 11.7 | 115 | 216.0 | 0.54 |
| Madaras | BH | 5 | 46 | 25 | 0.4 | 3 | 8.3 | 0.60 |
| Ciumeghiu | G | 12 | 92 | 35 | 2.9 | 6 | 45.1 | 0.50 |
| Cighid | HBG | 10 | 72 | 25 | 2.0 | 6 | 37.2 | 0.60 |
| Beius | HB | 25 | 83 | 30 | 5.5 | 15 | 104.9 | 0.60 |
| Macea | HGB | 15 | 65 | 25 | 2.5 | 8 | 42.2 | 0.53 |
| Curtici | HGB | 22 | 63 | 25 | 3.5 | 14 | 70.2 | 0.64 |
| Dorobanti | GB | 18 | 60 | 25 | 2.6 | 9 | 41.5 | 0.50 |
| Sofronea | HB | 6 | 42 | 25 | 0.4 | 3 | 6.7 | 0.50 |
| Iratos | IB | 5 | 40 | 20 | 0.4 | 3 | 7.9 | 0.60 |
| Arad | B | 12 | 40 | 25 | 0.8 | 7 | 13.8 | 0.58 |
| Nadlac | IHB | 10 | 78 | 30 | 2.0 | 8 | 50.6 | 0.80 |
| Sannicolau | IHBG | 50 | 78 | 30 | 10.0 | 35 | 221.6 | 0.70 |
| Saravale | HB | 8 | 75 | 25 | 1.7 | 5 | 33.0 | 0.62 |
| Tomnatic | GB | 45 | 80 | 30 | 9.4 | 22 | 145.1 | 0.49 |
| Lovrin | HGB | 40 | 81 | 30 | 8.5 | 30 | 132.0 | 0.49 |
| Periam | HB | 10 | 70 | 25 | 1.9 | 6 | 35.6 | 0.60 |
| Jimbolia | IHGB | 50 | 82 | 30 | 10.9 | 35 | 240.1 | 0.70 |
| Teremia | IHB | 15 | 85 | 30 | 3.5 | 6 | 43.5 | 0.40 |
| Comlosu | HB | 10 | 81 | 25 | 2.3 | 6 | 44.3 | 0.60 |
| Grabat | IB | 6 | 80 | 30 | 1.3 | 3 | 19.8 | 0.50 |
| Beregsau | IB | 6 | 75 | 25 | 1.3 | 3 | 19.8 | 0.50 |
| Timisoara | HB | 15 | 45 | 25 | 1.3 | 10 | 26.4 | 0.67 |
| Herculane | B | 75 | 52 | 25 | 8.5 | 50 | 148.0 | 0.67 |
| Olt Valley | HB | 25 | 92 | 30 | 6.5 | 16 | 130.8 | 0.64 |
| North Bucharest | HB | 35 | 62 | 25 | 5.4 | 15 | 65.0 | 0.43 |
| **TOTAL** | | | 890 | | 152.4 | 585.0 | 2870.7 | |

**Utilisation of geothermal energy**

Due to the difficulties encountered by the Romanian economy, during 1995-2002, only three new geothermal projects were completed, one for direct use and two for bathing and swimming. The geothermal operations completed before 1995 continued to operate, with some exceptions due to the vanishing of the users, situation obviously created by the reduction (about 50%) of the greenhouse area heated by geothermal energy. The utilisation of geothermal energy as of 31 December 2002 is shown in Table 3. In the 38 "geothermal localities" are operating 96 wells (of which 37 exclusively for bathing or balneology) totalling -at maximum utilisation- 890 kg/s flowrate, and weighted average temperatures of 71°C for inlet and 28°C for outlet.

The total capacity is 152 $MW_t$ that produces annually 2,870 TJ. The main direct uses of geothermal heat are: space heating 37.4%, bathing and swimming including balneology 30.4%, greenhouse heating 23,1%, industrial process heat 7%, and fish farming and animal husbandry 2.1%, the capacity factor being 0.6. By type of utilisation the actual situation in Romania is shown in Table 4.

During 1995-2002, the total investments in geothermal project (Table 5) were 26 million USD, 13% less than during 1990-1994 and 27% less than during 1985-1989 respectively, all projects being funded from the State Budget. Out of the total investments in geothermal projects the cost of drilling the 14 wells represents 70%, the rest of 30% being invested in direct use.

*Table 4: Summary table of geothermal direct heat uses as of 31 December 2003*

| Use | Installed Capacity[1)] (MWt) | Annual Energy Use[2)] (TJ/yr) | Capacity Factor[3)] |
|---|---|---|---|
| Space Heating[4)] | 53 | 1073 | 0.64 |
| Air Conditioning (Cooling) | | | |
| Greenhouse Heating | 40 | 665 | 0.52 |
| Fish and Animal Farming | 3 | 60 | 0.63 |
| Agricultural Drying[5)] | | | |
| Industrial Process Heat[6)] | 14 | 201 | 0.45 |
| Snow Melting | | | |
| Bathing and Swimming[7)] | 42 | 871 | 0.65 |
| Other Uses (specify) | | | |
| **Subtotal** | 152 | 2870 | 0.60 |
| Geothermal Heat Pumps | | | |
| **TOTAL** | 152 | 2870 | |

*Table 5: Total investments in geothermal in (1999) USD*

| Period | Research &Development Incl. Surface Exploration & Exploration Drilling Million US$ | Field Development Including Production Drilling & Surface Equipment Million US$ | Utilisation | | Funding Type | |
|---|---|---|---|---|---|---|
| | | | Direct Million US$ | Electrical Million US$ | Private % | Public % |
| 1985-1989 | 21 | 7 | 5 | | | 100 |
| 1990-1994 | 15 | 5 | 7 | | | 100 |
| 1995-2003 | 9 | 11 | 7 | | | 100 |

## CONCLUSIONS

During 1995-2003 the geothermal activity in Romania stagnated due to the economic difficulties that the country faces with. Compared to the period of 1990-1994 there are no changes as to geothermal energy use (2,870 TJ in 1999 compared to 2,753 TJ in 1994), only the installed capacity increased from 137 $MW_t$ in 1994 to 152 $MW_t$ in 2003 regarded to retechnologisation of some operations and completion of three new ones.

Compared to the period of 1990-1995 it is observed a fall in allocation of professional personnel (by ca. 20%) due to the reduction of geothermal activity at both operators (Foradex and Transgex). The fall of investments in geothermal projects during 1995-1999 is 12% compared to the previous period of 1990-1995. All investments were completed exclusively from funds allocated from the State Budget.

The main obstacle for the geothermal development Romania is the scarcity of the domestic investment capital. In order to stimulate the interest of potential investors from developed countries and to comply to the requirements of the large international banks, an adequate legal and institutional framework has been created, adapted to a market oriented economy.

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