



## GEOTHERMAL DEVELOPMENT IN ROMANIA

**Marcel Rosca**  
University of Oradea,  
ROMANIA

### ABSTRACT

Romania is located in Central Europe, at the crossing of the 45°N parallel with the 25°E meridian, north to the Balkan Peninsula, on the lower course of the Danube river, and on the Black Sea coast. Geological research carried out between 1960 and 1980 proved the existence of significant geothermal resources in some regions, mainly in the western part of the country. At present, the geothermal potential is only partially used for district heating, greenhouse heating, industrial processes, and health bathing. Future development is desirable and possible, as some of the obstacles that delayed are now being overcome.

### 1. INTRODUCTION

Romania is a republic located in Central Europe, the south-eastern Carpathian sector, at the crossing of the 45°N parallel with the 25°E meridian, north to the Balkan Peninsula, the lower course of the Danube river, on the Black Sea coast. Borders: 620 km with the Republic of Moldavia, 591 km with Bulgaria, 570 km with Ukraine, 546 km with Yugoslavia, 442 km with Hungary, and 245 km the Black Sea Coast. The capital is Bucharest, a city with about 2,067,000 inhabitants. Other main cities are: Constanta, Iasi, Timisoara, Cluj-Napoca, Brasov, Galati, Craiova, Ploiesti, Oradea, Arad and Targu-Mures.

The formation and evolution of the Romanian territory is closely related to the Carpathian Mountains, part of the great Alpine-Himalayan chain. The total surface area of Romania is 238,390 km<sup>2</sup>. The relief comprises three major summits: the highest are the Carpathian Mountains (31%), the middle corresponds to the sub-Carpathian hills and plates with altitudes of 200 - 800 m (36%), the lowest being the plains, meadows and the Danube Delta (33%). The relief is displayed in an amphitheatre shape, with the Transilvanian Plateau inside the Carpathian Arc. The Romanian part of the Carpathian Mountains is usually divided in three parts: Oriental, Meridional and Occidental, the maximum altitude being 2,543 m in the Făgăraş Mountains. The passing from mountains to plains is made by cliffs to west and south-west and by sub-Carpathian hills to the east and south. East and south-east to the Carpathian Mountains are the Moldavian Plateau, the Dobrogea Plateau (Hercynian plate heavily eroded), as well as the Danube Delta (5,000 km<sup>2</sup>) and the Black Sea coast.

The climate is of a transitional temperate continental type, with oceanic influences in the West, Mediterranean in the south-west and excessive continental in the north and east. The annual mean temperatures differ with latitude, being 8°C in the north and 11°C in the south. In the Western Plain (Timișoara-Oradea), the annual mean temperature is 10.2°C.

Romania's geographical location, which overlaps the contact of the Alpine orogenic belt with the old East European craton, accounts for a highly diversified geological structure. A general look at the geology shows that the Carpathian area, belonging to the northern branch of the peri-Mediterranean Alpine folded chains, has been divided into structural units which generally group together nappes of similar type and of synchronous age of tectogeneses. Two large Neogene Molasse basins, Transilvanian and Pannonian, are superimposed on the folded units. A Sarmato-Pliocene Molasse foredeep borders the folded chain outwards.

Except for the ophiolitic assemblage, the Alpine magmatic activity shows three igneous periods: an ensialitic, predominantly alkaline, event (Jurassic) known in the South and East Carpathians, and two subduction calc-alkaline events, the first during the Upper Cretaceous and Paleogene, the second during the Neogene.

The Carpathian foreland groups platform areas of different ages. The oldest one is the Moldavian platform, belonging to the Epi-Algonian East European craton, situated in front of the East Carpathians. An Epi-Hercynian platform runs south and westwards to the previous one. The outer part of the Danubian realm has been considered a direct prolongation of the Moessian Platform.

The Pannonian Basin - a fairly large Neogene intra-mountain depression - was formed during and after the Miocene tectogeneses affected the Carpathian area. The basin was created by extension and attenuation of the lithosphere, together with subsidence that began in the Badenian and continued as a rapid subsidence in the Pannonian. During this period of time, a large amount of sediments accumulated, with thicknesses of up to 4 km in the Western Plain of Romania. The attenuation of the lithosphere resulted in a high heat flow anomaly, with values of 85-100 mW/m<sup>2</sup>. The Pannonian Basin is the "hottest" area in Eastern and Central Europe. The geothermal reservoirs in the permeable rocks of the Pannonian Basin are a result of this high heat flow. They comprise multilayered confined aquifers of regional extent at the bottom of the Upper Pannonian and local ones in rocks of the Lower Pannonian or in the sedimentary rocks of the down-dropped basement.

## 2. THE GEOTHERMAL RESOURCES

The exploration and research for geothermal resources began in Romania in 1962-1965. The first geothermal wells were drilled in the Western Plain (Oradea, Felix, Calacea and Timisoara areas). At present, over 200 drilled wells show the presence of geothermal resources. The drilling of most of these wells was funded by the Romanian government as part of the Geological Research Program. The completion and experimental exploitation of over 100 wells in the past 15 years, enabled the evaluation of the exploitable heat resources from geothermal reservoirs. The proven reserves (with the already drilled wells exploited by downhole pumps) are about 200,000 TJ for 20 years.

The total installed capacity of the existing wells for energy use is 320 MWt (for a 30°C reference temperature). At present, only 137 MWt are used from 60 wells that are producing hot water in the temperature range of 55 to 115°C. For 1994, the annual energy utilisation from these wells was about 1,900 TJ (45,000 toe), with a load factor of 63%. More than 80% of the wells are discharged in artesian flow, and 18 wells require anti-scaling chemical inhibition (Cohut, 1992).

The main energy uses of geothermal energy are:

- Space heating and domestic hot water, 53%;
- Greenhouse heating, 34%;
- Industrial process heat (wood drying, milk pasteurisation, flax and hemp processing), 11%;
- Fish farming, 2%.



About 30 wells are used for health and recreational bathing. The total flow rate from these wells is over 360 l/s, with water temperatures ranging from 35 to 65°C. In 1993, the average extracted flow rate was 275 l/s, with an annual utilisation of 870 TJ. Geothermal water is currently used in 16 thermal spas that have a treatment capacity of over 550,000 people per year. Geothermal water is also used in 24 open pools and 7 indoor swimming pools. In 1993, the total energy savings in health bathing was about 21,000 toe.



Figure 1: Geothermal fields in Romania

**The main geothermal systems** discovered in Romanian territory (Figure 1) are found 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 Panonian Basin and of Malm-Aptian age in the Moesian Platform.

**The Pannonian geothermal aquifer** is multi-layered, confined and is located in the sandstones at the basement of the Upper Pannonian in an approximate area of 2,500 km<sup>2</sup> along the western border of Romania from Satu Mare in the north to Timisoara and Jimbolia in the south. The aquifer is situated at a 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 water temperature at surface 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. Scaling is prevented by injecting a solution of sodium tri-poliphosphate with a concentration of 3 g/m<sup>3</sup> extracted water. The combustible gases, mainly methane, are separated from the geothermal water. The gas/water ratio (GWR) varies between 0.8 and 2.0 Nm<sup>3</sup>/m<sup>3</sup>. These gases can be used by burning in boilers, therefore the thermal potential of the well is increased by 15-20%. The exploitable heat reserves for the next 20 years are estimated to be over 95,000 TJ with the existing wells and generalised downhole pumping exploitation (100,000 toe/yr.). The whole geothermal system has no recharge and the drawdown depends on the extracted volume. In average, the specific volume of production is 3-5×10<sup>6</sup> m<sup>3</sup>/bar draw down after 12-14 years of production. The main geothermal areas are: Satu Mare, Acas, Marghita, Sacuieni, Salonta, Curtici, Lovrin, Tomnatic, Sannicolau Mare, Jimbolia and Timisoara (Stefansson, 1988).

**The Oradea geothermal reservoir** is located in the Triassic limestone and dolomites at depths of 2,200-3,200 m, in an area of about 75 km<sup>2</sup>, and is exploited by 12 wells with a total artesian flow rate of 140 l/s with well head temperatures of 70-105°C. There are no dissolved gases and the mineralisation is lower than 1.2 g/l. The water is of calcium-sulphate-bicarbonate type. The Triassic aquifer Oradea and the Cretaceous aquifer Felix Spa, are hydrodynamically connected and are part of the active natural circuit of water. The water is about 20,000 years old and the recharge area is in the northern edge of the Western Carpathian Mountains. 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, which can be prevented by reinjection. The Felix Spa reservoir is currently exploited by 6 wells, with depths between 50 and 450 m. The total flow rate available from these wells is 210 l/s. The geothermal water has well head temperatures of 36-48°C and is drinkable.



**The Borş geothermal reservoir** is located about 6 km northwest of Oradea, in the same fissured carbonate formations. This is a tectonically closed aquifer, with a small surface area of 12 km<sup>2</sup>. The geothermal water has a mineralisation of 13 g/l, a GWR of 5 Nm<sup>3</sup>/m<sup>3</sup> and a high scaling potential. The dissolved gases are 70% CO<sub>2</sub> and 30% CH<sub>4</sub>. The reservoir temperature is above 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, 3 wells are exploited, with a total flow rate of 50 l/s and 2 other wells are used for reinjection, at a pressure that does not exceed 6 bar. The geothermal water is used for heating 6 ha of greenhouses. The wells are producing with well head pressures of 10 to 15 bar and a well head temperature of 115°C. The gases are partially separated at 7 bar, the operating pressure, and water is passed through the heat exchangers and reinjected.

**The Otopeni geothermal reservoir** is located north of Bucharest. It is only partially delimited (about 300 km<sup>2</sup>). The 12 wells that were drilled show a huge aquifer located in fissured limestone and dolomites, situated at depths of 1,900-2,600 m, belonging to the Moesic Platform. The geothermal water has temperatures of 58-80°C and a mineralisation of 1.5-2.2 g/l, with a high content of H<sub>2</sub>S (over 25 ppm). Therefore, reinjection is compulsory. Production is carried out using downhole pumps, the water level being at about 80 m below surface.

**The Cozia-Călimaneşti geothermal reservoir** (Olt Valley) is located in fissured siltstones of Senonian age, at depths of 1,900-2,200 m. It is tapped by 3 wells, with an artesian flow rate of 20-25 l/s, well head pressures of 16-20 bar, and well head temperatures of 90-95°C. The mineralisation is 14 g/l and there is no scaling. The GWR is 2.0 Nm<sup>3</sup>/m<sup>3</sup> (90% CH<sub>4</sub>). After 10 years of exploitation there is no interference between the wells, and no pressure drawdown. The installed capacity of the existing wells is 18 MWt (3.5 MWt from gases); at present only 8 MWt are being used. Utilisation is mainly for space heating, but also for health and recreational bathing.

Table 1: The main parameters of the Romanian geothermal systems and utilisation

Parameter	U/M	Oradea	Borş	Western Plain	Olt Valley	North Bucharest
Type of reservoir		Carbonate	carbonate	sandstone	gritstone	carbonate
Area	km <sup>2</sup>	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
Gas/water ratio (GWR)	Nm <sup>3</sup> /m <sup>3</sup>	0.05	5-6.5	0.5-2.5	2-2.8	0.1
Type of production		Artesian	Artesian	Art.+Pump.	Artesian	Pumping
Flow rate/well	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	MWt	58	25	210	18	32
Exploitable reserves (20 yr)	MW/day	570	110	4,700	190	310
<b>Main utilisation</b>						
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	-	-
Bathing	operations	5	-	8	3	2



### 3. CURRENT STATUS OF GEOTHERMAL DEVELOPMENT

Before 1990, the entire geothermal research and development were supported by the State Budget, in the so called 'centrally planned economy'. This is the reason why, until 1986-87, the use of geothermal water and heat was free of any taxes, experimental exploitation being considered as part of the geological and technological research. This way, the rural communities and the small urban users had the advantage of using geothermal water not necessarily for space heating. They also used it for local small industrial purposes, such as timber drying, milk pasteurisation, wild fruits and mushroom drying, etc. The cascaded utilisation yielded good results, even with the low flow rates available by artesian discharge. In this way, small but efficient installations were accomplished for separating and using the combustible gases from geothermal waters. Small pilot plants provided the experience needed for latter fulfilment of some large scale commercial projects.

At present, the geothermal resources are exploited by two geological research companies, both state owned, that sell the thermal energy at an average price of 2.5 USD/MWht. This price is about three times lower than the one asked by the National Electricity Corporation (CONEL which covers 40% of the national heat demand and 95% of the national electricity demand) for the thermal energy produced by the fossil fuel fired co-generation power plants. In drilling a new well, the price of the geothermal heat delivered would be about half of the price of the heat delivered by co-generation power plants. About 50% of the thermal energy delivered to domestic users is subsidised by the state, more than 60% of the people living in large and medium cities being connected to district heating systems. The geothermal water for recreational and health bathing is usually supplied free of charge from wells drilled for geological research. Figure 2 shows total produced geothermal energy from 1974 to 1994.

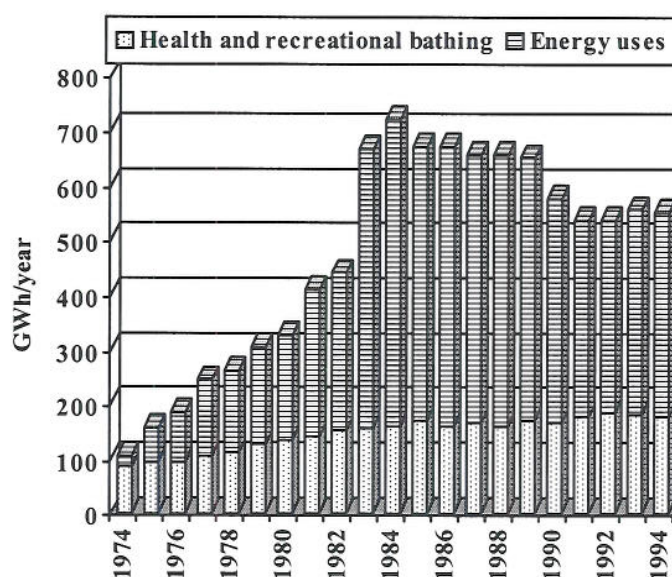


Figure 2: Total produced geothermal energy

Probably the most successful direct utilisation of the geothermal energy in Romania (apart from health bathing) is greenhouse heating. The heating systems are usually aerial smooth or finned steel pipes positioned beside side walls and along the plant canopy or below the cultivation benches. The most common glass-house unit has an area of 0.5 ha (72x72 m). All glass covered greenhouses heated by geothermal energy are backed up by either liquid fuel or gas fired peak load boilers for the very cold periods of the year. These boilers have an installed capacity of 25-40% of the full load (calculated for a minimum outside temperature of -15°C). The current status of greenhouses heated by geothermal energy is shown in Table 2.

The fact that more than 50 wells are not exploited at present is mostly due to the lack of available investment capital. The thermal power potential unused in this way is over 100 MWt. Assuming that the drilling cost is about 50% of the total investment cost of a new geothermal operations, the technology upgrading and on-line setting of the existing wells and user equipment show very good developmental conditions in Romania. The significant heat demand near the geothermal fields also presents a favourable perspective, as well as the existence of specialists and skilled workers with long experience in geothermal well drilling and exploitation.

Table 2: Situation of greenhouses heated by geothermal energy in Romania

County	Locality	Greenhouses (ha)		Energy use	Savings
		1987	1997	TJ/yr	toe/yr
Satu Mare	Acâș	1.5	3.0	36	860
	Tășnad	0.5	0.5	9	215
	<b>Subtotal</b>	<b>2.0</b>	<b>3.5</b>	<b>45</b>	<b>1075</b>
Bihor	Săcuieni	2.0	0.5	9	215
	Mihai Bravu	1.0	0.5	8	205
	Oradea	2.0	2.0	55	1310
	Borș	10.0	8.0	135	3225
	Salonta	2.0	0.0	-	
	Ciumeghiu	0.0	1.0	11	
	<b>Subtotal</b>	<b>17.0</b>	<b>12.0</b>	<b>218</b>	<b>5215</b>
Arad	Macea	3.0	1.5	20	480
	Curtici	6.0	3.5	42	1000
	Dorobanți	6.0	6.0	110	2630
	<b>Subtotal</b>	<b>15.0</b>	<b>11.0</b>	<b>172</b>	<b>4110</b>
Timiș	Sînnicolau	4.0	1.0	10	240
	Tomnatic	11.5	7.0	120	2870
	Lovrin	6.0	2.0	22	530
	Jimbolia	2.0	1.5	20	480
	Teremia	0.5	0.5	9	215
	<b>Subtotal</b>	<b>24.0</b>	<b>12.0</b>	<b>178</b>	<b>4335</b>
Bucharest	Otopeni	-	0.5	10	240
<b>TOTAL</b>		<b>58</b>	<b>39.0</b>	<b>626</b>	<b>14975</b>

The large majority of the 56 geothermal operations located in 24 areas (60 production and 5 reinjection wells) require modernisation (deep well pumps to increase the flow rates, plate heat exchangers, reliable measurement and control equipment, better insulated transport pipelines with lower specific heat loss, etc.). The technological upgrading of the existing geothermal systems - as a first step to the rehabilitation of the Romanian geothermal industry - requires important investment funds that are not available at present, due to the lack of domestic capital.

The existing market offers favourable conditions for the full development of the 350 MWt available from the already drilled wells, out of which only 130 MWt are currently used. The exploitation of some geothermal resources could be increased by drilling new production and reinjection wells.

Regarding the environmental impact of the geothermal development, general conditions are also favourable in Romania. It is possible to reinject a part of the spent geothermal waters with a mineral content above the approved standards, the rest being discharged in rivers, providing conditions for dilution according to present legislation

The only state-of-the-art geothermal system in Romania is the University of Oradea heating system. The thermal energy demand for space and tap water heating of the University of Oradea has been supplied since 1983 by the geothermal water produced in artesian flow (max. 30 l/s, 84°C) by a well drilled on campus. As the Geothermal Research Centre of the University of Oradea is now installing a new pilot binary cycle power plant with an expected 1 MW power, a larger geothermal fluid flow rate is needed. The production flow rate has been increased to 50 l/s by installing a line shaft pump at a depth of 150



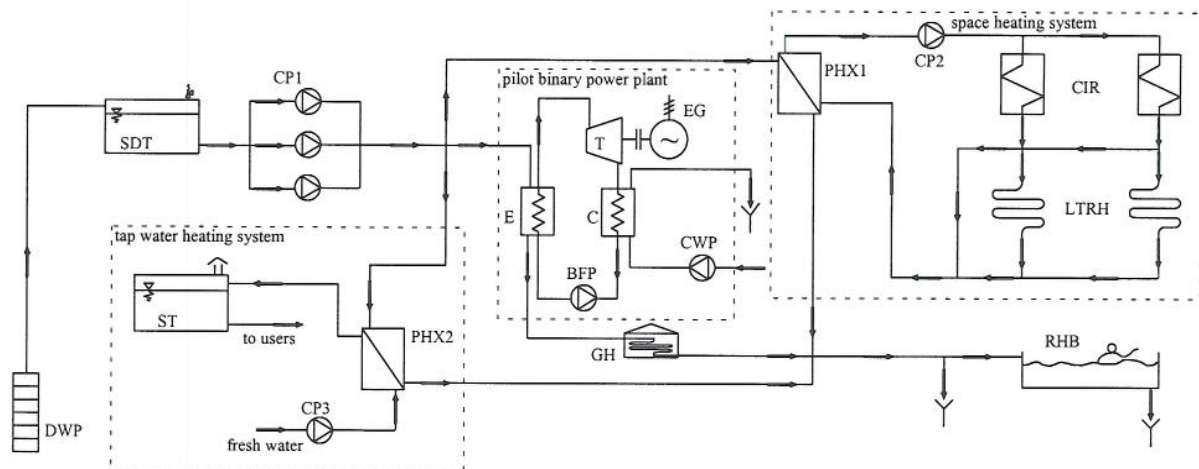


Figure 3: Layout of the geothermal cascaded use system at the University of Oradea (Rosca and Maghiar, 1995)

m in the geothermal well. At the same time, the entire system has been modernised and equipped with a SCADA system. The existing shell-and-tube heat exchangers have been replaced by stainless steel plate heat exchangers, the thermal insulation of all piping has been renewed, and the system has been modified to allow for later development of cascaded uses. All this activity has been carried out under an EUREKA project by the University of Oradea in collaboration with a consortium comprising Icelandic, Danish and Norwegian companies. The layout of the envisaged cascaded use system is shown in Figure 3 (Rosca, 1993; Antics et al., 1998; Rosca and Maghiar, 1995).

Further development is envisaged for the near future in some other areas. Probably the first one will be the heating system in Olt Valley Spas (Cozia, Caciulata, and Calimanesti), for which an INCO-Copernicus project proposal has just been approved by the European Commissions. The project for a district heating system using geothermal water and separated combustible gasses will be carried out by a research and design institute from Bucharest (ICPET CERCETARE S.A.) in collaboration with a consortium comprising French, Greek, Slovak, and Slovenian companies.

Another development that might start in the near future is the modernisation and development of the system existing in the City of Oradea, based on the feasibility study jointly compiled by the French Geoproduction Consultants S.A. and the Romanian Geofluid S.A. companies, which clearly shows the opportunity and necessity of investments in modernisation and technology upgrading, as well as the economic viability of such an investment. For a capital investment cost of about 12 million USD, the discounted pay-back time is 5.8 years, and the internal rate of return 22%.

#### 4. MAIN PROBLEMS OF GEOTHERMAL ENERGY PROMOTION

Generally speaking, the available geothermal resources are exploited far below the well and reservoir capacity, for several reasons, including:

- Lack of adequate production facilities;
- Impossibility to reinject the spent geothermal water into the sandstone reservoirs in acceptable economic conditions;
- Technological shortcomings, as all equipment was supplied in the early 1980's by the Romanian industry and is not able to meet the requirements of modern geothermal heat plants.

This obviously leads to productivity indices below normal ratings and highlights the need for



technological upgrading of vital system segments, such as: downhole pumping units, variable speed drives, high performance heat exchangers, automation, remote control and regulation.

In the last 7 years, Romania has passed through a difficult transition process towards a so called social market economy. The envisaged economic system requires an almost completely new legislation. The restructuring of the national economy started through large scale privatisation, encouragement of foreign capital inflow, massive loans from the International Monetary Fund and international banks. The time is also right for geothermal development, but the promotion of a geothermal project and the exploitation of its resources imply the creation of appropriate legal, financial and organisational structures.

**Legal aspects.** One of the most important constraints for geothermal development in Romania was the absence of an adequate legislation regarding the prospecting and exploitation of underground resources (Mining Law). A new Mining Law has been adopted this year. According to this new legislation, the state is the owner of all mineral resources. The law also defines the conditions under which the state can grant, and a company can ask and acquire, the concession of geothermal wells and/or perimeters. The rights and obligations of the state and the company obtaining the concession are also clearly specified by the new law. Other related laws to be released in the near future are the Laws for Concessions, for Local Administration and Budget, for Public Property, etc.

The release of legal possibilities for taxing incentives is also required for encouraging investments in geothermal energy exploitation by tax allowances, or at least reductions, and by credits with low interest rates, because it is a less expensive energy source, creates new jobs, reduces the hard currency spent for fossil fuel import, and reduces environment pollution.

**Financial support.** For new operations, including the drilling of new wells, the state budget should cover the geological risk (when results are negative). The State should also assist in finding domestic and foreign financial support for technological upgrading and future development, by encouraging domestic capital investment (from the State Budget, municipalities, commercial banks, groups of investors, etc.), and by guarantying foreign loans.

**Organisational restructuring** - including privatisation - is necessary because, at present, the geothermal resources are only exploited by two state owned geological research companies. These are mainly financed from the State Budget, and geothermal uses represent only about 10-15% of their activity. The founding of local companies strictly specialised in geothermal resource exploitation is also required, as these could be more easily privatised.

**Demonstration projects** will be useful for showing potential future investors and users the technological, economical and environmental advantages of geothermal district heating. These pilot plants should receive financial support from the European Community via the assistance programs for Central and Eastern Europe, such as the INCO-Copernicus project for the Olt Valley heating system.

**Educational and informational needs.** Geothermal energy utilisation has specific particularities in the development process, such as the exploration phase, drilling, reservoir engineering and management, geothermal water chemistry, etc. As highly trained specialists were needed for geothermal development, the only possibility was to train them abroad. At the Faculty of Energy Engineering of the University of Oradea, a new specialisation in Non-conventional and Renewable Energy Sources started in 1994, and since 1995 M.Sc. courses in solar and geothermal energy utilisation are offered. The training of other scientists, engineers and economists in specialised Centres abroad (New Zealand and mainly Iceland), helped create a team of specialists able to train new professionals for the geothermal industry. The University of Oradea employs 5 graduates from the UNU Geothermal Training Programme in Reykjavik, Iceland, two others who had a shorter training courses related to the EUREKA project mentioned before, and an Associate Professor who graduated from the Auckland Geothermal Institute in New Zealand. Two other graduates from the Auckland Geothermal Institute work in Bucharest but are no longer involved in geothermal jobs.



International technical and scientific co-operation for the development of geothermal energy utilisation systems in Central and Eastern Europe, and easy access to an international information network, would be an important aid to all specialists working in this field, and for the development of the Romanian geothermal industry. For education and training of people involved in geothermal development from Central and Eastern Europe, an International Geothermal Training Centre has been created at the University of Oradea, offering short, medium and long term training at both undergraduate and graduate levels.

## REFERENCES

- Antics, M., Cohut, I., Rosca, M., 1998: Development of the geothermal heating facilities of the City of Oradea, Romania. *Proceedings of the International Symposium Mineral and Thermal Groundwater*, Miercurea Ciuc, Romania, 3-10.
- Cohut, I., 1992: Current status and prospects of the Romanian geothermal industry. *Report presented at the International Seminar on Geothermal Energy, Oradea, Romania*, 5 pp.
- Rosca, M., 1993: *Economical and technical assessment of some geothermal development scenarios for Oradea, Romania*. UNU Geothermal Training Programme, Reykjavik, Report 13, 44 pp.
- Rosca, M., and Maghiar, T., 1995: Cascaded uses of the geothermal water at the University of Oradea, Romania. *Proceedings of the World Geothermal Congress 1995, Florence, Italy*, 3, 2273-2276.
- Stefansson, V., 1988: *Research and utilisation of geothermal resources. Phase II*. Report to the United Nations on the mission Rom-82-005, United Nations, New York, USA, 76 pp.