# GEOTHERMAL RESOURCES IN ROMANIA
## -RESULTS AND PROSPECTS-
1994

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ABSTRACT

Research and the exploitation of geothermal reservoirs started in Romania in 1964. This activity was coordinated, financed and monitored hy the Ministry of Geology, and the actual works were performed hy the former I.P.L.G.S. . currently FOHADEX S.A. company. A government decision taken in 1983 stipulated the establishment of 9 new companies for geological surveys and explorations. As a results, parts of Romania's territory were ascribed to different companies tor various research and the exploration of the geothermal resources. The situation remained the same also after 1990, when autonomous trade companies for research and exploration of mineral resources were established.

The paper addresses global information concerning the geothermal resources and their use at the 1994 in Romania.

KEY WORDS:

Romania drilling, district heating. spar, agencies

## 1. INTRODUCTION

Romania. a Central European country situated north of Greece and south of Poland, has rather significant geothermal potential, which is studied according to the classical approach adopted by most of the members of the International Geothermal Association, and which is used locally, as a function of the demand and of the technical possibilities.

Geothermal exploration started in Romania in 1964, and 195 wells were drilled through 1994. These were pot into production. as they were completed and according to the possibilities of use.

According to the characteristics of the geothermal reservoirs and to the territorial position. six distinct hydrogeothermal systems were identified, distributed within the main geological provinces of Romania as follows (APPENDIX 1 - Geothermal thematic map):

4 in the western part, near the border with Hungary and Serbia, in the Pannonian Basin:

1 in the gorge of Olt river, in the median part of Southern Carpathians, within the Getic Depression;

I in the Moesian Platform area, north of Bucharest.

At the present time (October 1994), 54 geothermal wells are producing, which provide water at temperatures ranging between 40 and 105°C, wilh the following applications:

- district heating - about 3000 dwellings;
- greenhouse healing - about 45 ha;
- preparation of sanitary hot water - far ahout 15000 dwellings;
- preparation of industrial hot water for ahout 10 factories (timber and cereals drying, milk pasteurization, hemp processing);
- balneological uses.

## 2. STUDY AREAS

The currently investigated hydrogeothermal systems are situated within three broad geological provinces of Romania (Appendix 1 the map), as follows:

A. The western part of the territory - called the "Pannonian Depression" is the "hottest" zone of Romania and is characterized by a crystalline pre-Mesozoic basement, dissected in horsts and grabens.

The uplifted areas of the hot basement were associated to favorable *permeability conditions of the detritic Pannonian and Miocene* formations, as well as of Mesozoic carbonate (fractured and fissured) formations, resulting in hydrothermal systems that are among the most important.

B. The Getic Foredeep, located in front of the Southern Carpathians, has a sunken and highly tectonically disturbed crystalline basement, covered by alluvial Cretaceous deposits that are crossed by faults along which thermomineral water flows.

Within the area investigated by drillholes, situated in the Cozia - Caciulata - Calimanesti - Olanesti regions, an important detritic fissured (highly fissured quartzitic sandstones with carbonate cement) reservoir was identified, with artesian water and intense thermality.

C. The *Moesian Platform - a geological province situated in the* southern part of Romania, displays a complex structure, as a result of the dissection of the deposits in tectonic blocks and of their downthrowing along deep fractures striking South-North. The geologic formations included in the region basement cover an almost complete stratigraphic sequence, beginning with the Pre- Cambrian - within the basement - and ending with Quaternary deposits at the surface.

The formation of interest for geothermal water consists of fissured, fractured and karstified carbonate deposits of Late Jurassic - Early Cretaceous age, that forms a hydrogeothermal system 800 - 1000 m thick.

## *3. RESULTS*

Appendix 2 - TABLE 1 indicates the number of drilled wells, their present day status, the depth of the reservoir, the temperature and the average flowrate for each field and geological province investigated through 1994.

Appendix 3 - TABLE 2 indicates the chemical composition of the *geothermal water presently extracted from the indicated fields.*

s indicated by TABLE 2, the geothermal water from the investigated areas, which is used for various purposes, has low TDS. However, in the Western Plain and the Western Banat regions, in order to avoid scaling, various inhibitors produced in Romania, such as sodium tripolyphosphate, Ponilit and IC 2000, are injected in the water circuit.

WELLS DRILLED FROM 1964 TO 1994 IN ROMANIA FOR GEOTHERMAL WATER

Appendix 2 TABLE 1

| GEOLOGICAL PROVINCE RESERVOIR | PRODUCTION WELLS No | Depth of reserv. (m) | Flow rate ($m^3/h$) | Temp °C | kW Energy | Drilled wells 1994 Depth (m) | Exp wel | Abandon wells | Reinjection wells |
|---|---|---|---|---|---|---|---|---|---|
| **WEST PLAIN** Triassic reservoir fracturate carbonate | 13 | 1700-2600 | 2-30 | 70-105 | 250 6800 | - | 6 | 1 | 3 |
| WEST BANAT PANONIAN RESERVOIR granoulos sand and sandstone | 14 | 1300-2000 | 4-15 | 69-85 | 500 2800 | - | 46 | 10 | |
| **MUREŞ-CRIŞUL NEGRU** PANONIAN RESERVOIR sand and sandstone | 10 | 800-2000 | 2-9 | 62-72 | 200 1200 | 1 3500 | 6 | 6 | |
| **CRIŞUL NEGRU-SOMEŞ** PANONIAN RESERVOIR granoulos-sand and sandstone | 12 | 1000-1500 | 2-8 | 50-90 | 84-1300 | - | 20 | 23 | |
| **COZIA-CĂCIULATA** SENONIAN RESERVOIR fissured sandstone | 2 | 2200-2900 | 10-17 | 92-95 | 2200 3900 | 1 3000 | 1 | - | - |
| **MOESIAN PLATFORM** JURASSIC - CRETACEOUS RESERVOIR fissured carbonate | 3 | 400-2900 | 2-40 | 40-60 | 125 4500 | 2 1)2500 2)3000 | 17 | 1 | 1 |
| TOTAL | 54 | | | | | 4 | 96 | 41 | 4 |
| **TOTAL DRILLED WELLS = 195** | | | | | | | | | |

CHEMICAL COMPOSITIONOF THE GEOTHERMAL WATER IN ROMANIA

Appendix 3 TABLE 2

| | WEST PLAIN Triassic collector | Panonian collector WEST BANAT | Panonian collector MUREŞ-CRIŞUL NEGRU | COZIA Senonian collector | MOESIAN PLATFORM Jurassic-Cretaceous collector |
|---|---|---|---|---|---|
| TEMP.(°C) | 70-102 | 75-92 | 53-62 | 92-95 | 58-72 |
| pH | 6,7-7,3 | 7,0-8,3 | 6,5-8,0 | 6,0-6,5 | 6,9-7,2 |
| TDS (g/l) | 0,85 | 3,1-5,8 | 1,8-3,3 | 13,4-14,3 | 1,9-2,2 |
| $SiO_2$ (mg/l) | 43-64 | - | 23-69 | 18-61 | 16 |
| $HBO_2$ (mg/l) | abs. | 5-20 | 4,5-7,5 | - | - |
| Hardness (°ger.) | 35-48 | 2,1-4,0 | 1,2-4,5 | - | - |
| Phenols (mg/l) | abs. | 2,5-10,6 | 0,2-2,2 | abs. | abs. |
| $Cl^-$ (mg/l) | 15-50 | 370-1090 | 0,2-1,5 | 8150-8330 | 830 |
| $SO_4^{--}$ (mg/l) | 360-850 | 16-42 | 7-46 | 85-388 | - |
| $HCO_3^-$ (mg/l) | 150-300 | 1300-2400 | 670-1425 | 73-85 | - |
| $Na^+$ (mg/l) | 30-75 | 1050-1270 | 500-1480 | 3200-3520 | 580 |
| $NH_4^+$ (mg/l) | 0,3-2,2 | 9-26 | 0,5-1,6 | 7,3-10 | 1,2 |
| $Ca^{++}$ (mg/l) | 144-250 | 1-17 | 2,4-4,2 | 780-1924 | 106 |
| $Mg^{++}$ (mg/l) | 25-62 | 4-11 | 1,7-9,0 | 0,5-1,0 | 28 |
| $Fe^{++}$ (mg/l) | 0,7-3,4 | 0,5-1,7 | 0,1-7,0 | 0,1-4,6 | 0,5 |
| Water type | $CaSO_4$ | $NaHCO_3$ | $NaHCO_3$ | NaCl | NaCl |
| GWR ($Nm^3/m^3$) | 0,03 | 0,9-1,1 | 0,5-0,9 | 1-2 | 0,1 |
| Main constituents | $CH_4<CO_2$ | 90% $CH_4$ | 90-93% $CH_4$ | 94% $CH_4$ | $CH_4>CO_2>H_2S$ |

In Romania, geothermal energy is used in various domains, leading lo a saving on costs of classical fuel used for conventional energy production equivalent to 130 MW (thermal). The geothermal energy provides heating for more than 3000 conventional dwellings. several administrative buildings and commercial spaces and about 47 ha of greenhouses. Technological water is prepared for 10 industrial units. and domestic hot water is supplied for more than 16000 flats.

## Appendix 1

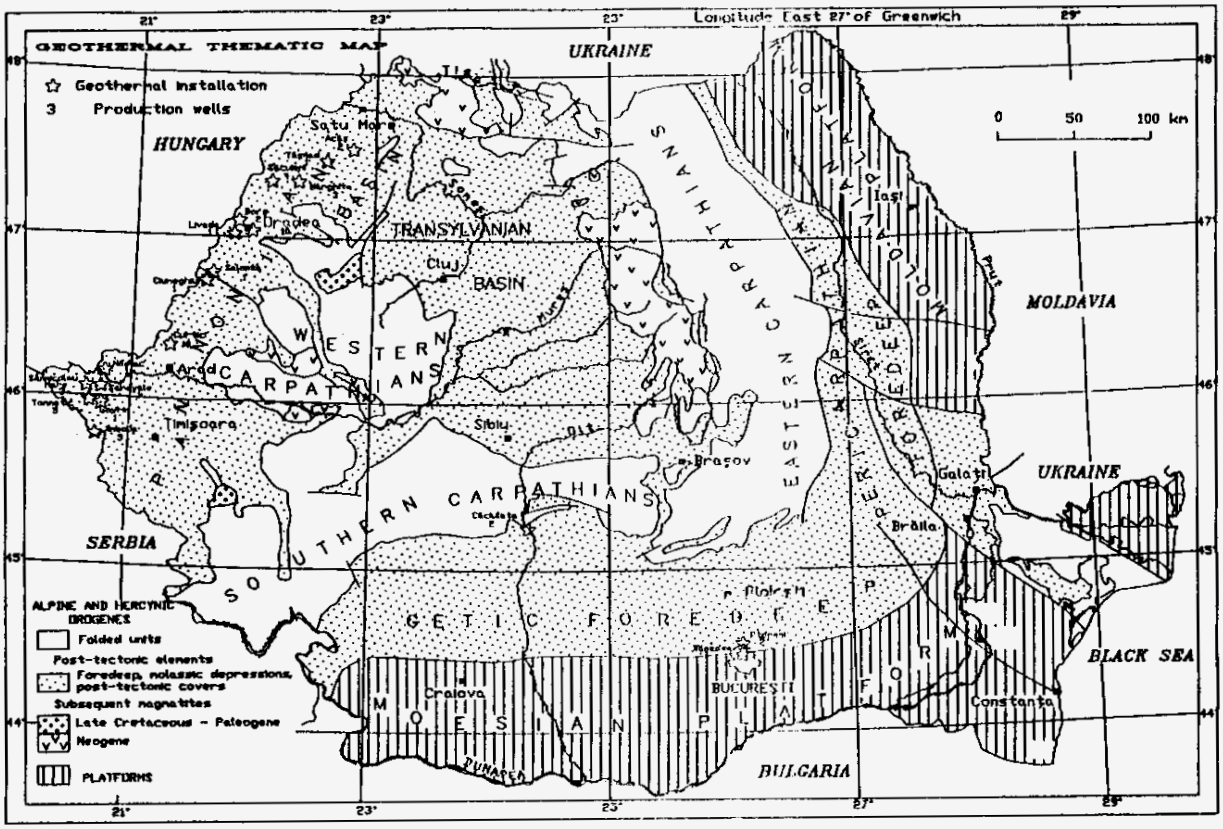


TABLE 3

GEOTHERMAL DEVELOPMENT STRATEGY

| LOCALITY / Geological province | RESOURCE: Investigation status | No. wells | Performance assessment: Discharge | Regime | Temp. | Heat output (WC rating) | Associate methane: Discharge | Heat output | Chemistry: TDS | $H_2S$ | Scaling | UTILIZATION: CURRENT Type | Max. heat output | PREVISIONAL Type | New consumers | Heat output | Distance from source | Production ability index | OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $m^3/h$ | | °C | MW$_{th}$ | $m^3/h$ | MW$_{th}$ | g/l | mg/l | | | MW$_{th}$ | | | MW$_{th}$ | Km | | |
| COZIA | Proven resource | 3 | 43 | Artesian | 95 | 2.7 | 82 | 0.8 | 15 | 21 | No | District heating | 2.6 | District heating | Dwellings in Calimanesti | 2.5 | 1 | No | |
| CACIULATA | | | 112 | Artesian | 93 | 6.9 | 167 | 1.6 | 15 | 31 | No | District heating | 3.1 | | | | | | |
| CALIMANESTI | | | 115 | Artesian | 92 | 6.9 | 127 | 1.2 | 15 | 4 | No | [illegible] | 2.5 | District heating | Dwellings in Ramnicu Valcea | more than 15.0 | 18 | No | |
| Getic depression | | | TOTAL | | | 16.5 | 376 | 3.6 | | | | | 8.2 | | | | | | |
| BUCURESTI (AVIATIEI DISTRICT) | Drilling under way | 1 | 200 estimated | Pumping | 55–60 | 3.5–4.6 | – | – | 1–3 | 10–30 | No | – | – | Sanitary hot water | Dwellings | 2.3 | 0.5 | Yes | Reinjection well additionally required |
| Moesian platform | | | | | | | | | | | | | | | | | | | |
| SANTANDREI | Drilling under way | 1 | 250 estimated | Artesian or Pumping | 125 | 24.7 | – | – | 1–2 | – | No | – | – | Electric [illegible] heating | Dwellings Seade dier | 4.3 | 2 | No | |
| West plain | | | | | | | | | | | | | | [illegible] | Dwellings | 6.8 | 1 | Yes | Drilling under way of the reinjection well |
| SNAGOV | Proven resource | 1 | 72 | Pumping | 80 | 4.2 | – | – | 2–3 | 10–30 | No | – | – | | | | | | |
| Moesian platform | | | | | | | | | | | | | | | | | | | |
| TOMNATEC | Proven resource | 6 | 25 | Artesian | 80 | 1.2 | 29 | 0.3 | 4 | – | $CaCO_3$ | Heating of greenhouses | 36.0 (9.0 with geoth. energy) | Heating | Greenhouses | 36.0 | 0.5–1.5 | Yes | Scaling problems solved |
| | | | 22 | Artesian | 79 | 1.0 | 30 | 0.3 | 4.5 | – | $CaCO_3$ | | | | | | | | |
| | | | 65 | Artesian | 77 | 2.8 | 75 | 0.7 | 3.7 | – | $CaCO_3$ | | | | | | | | |
| | | | 47 | Artesian | 80 | 2.2 | 47 | 0.4 | 3.6 | – | $CaCO_3$ | | | | | | | | |
| | | | 47/100 | Artesian Pumping | 74 | 2.1/4.4 | 47/100 | 0.4/0.8 | 4 | – | $CaCO_3$ | | | | | | | | |
| | | | 100 | Pumping | 74 | 3.9 | 100 | 0.9 | 4 | – | $CaCO_3$ | – | – | | | | | | |
| West Banat | | | TOTAL | | | 9.3/15.5 | 229/381 | 2.1/3.5 | | | | | | | | | | | |
| OLANESTI | Drilling under way | 1 | 36 estimated | Artesian | 80 | 1.7 | 36 | 0.3 | 15 | 5–30 | No | – | – | District heating Balneology | Hotels & Dwellings | 2.3 | 1.5 | No | |
| Getic depression | | | | | | | | | | | | | | | | | | | |
| OTOPENI | Proven resource | 3 | 100 | Pumping | 62 | 2.6 | – | – | 1.7 | 27 | No | District heating | 12.2 | District heating | Dwellings | 12.2 | 1–1.5 | Yes | –Improvement of the current district heating scheme foreseen –Existing reinjection well in exploitation since 1988 |
| | | | 100 | Pumping | 62 | 2.6 | – | – | 1.5 | 23 | No | | | | | | | | |
| | | | 100 | Pumping | 58 | 2.1 | – | – | 1.6 | 11 | No | | | | | | | | |
| Moesian platform | | | TOTAL | | | 7.3 | – | – | | | | | | | | | | | |

In some exploitation areas the best use of geothermal water is for balneology and for recreation facilities. Also 16 thermal spar operated using geothermal water, which are treating over 600 000 people per year; also geothermal water is used in 24 open pools and 7 indoor swimming pools. One such example is in the North Bucharest area, where the water produced from the 2641 Press House well, characterized hy the Bucharest Institute of Balneo Physical Therapy as sodium-chloride, low concentration iodide water, is used in external cures for balneo-therapeutic such as rheumatics and post-traumatic applications and peripheral nervous system applications.

The following examples are given to demonstrate how the geothermal water and its energy are used in specific places: (Appendix 1 Geothermal Thematic map).

1. West Plain - Oradea zone - domestic hot water for dwellings (including the first "doublet" using heat pumps made in Romania). the technological processing of milk, timber drying and thermal water used in swimming pools;

2. Bors (Oradea zone) and Tomnatec (West Banat) - heating of greenhouses;

3. Jimbolia (West Banat) - hot water far domestic use, industrial water for hemp and ceramic factories, heated swimming pools. etc;

4. Cozia - Caciulata - Getic Foredeep - domestic hot water supply and heating for hotels and commercial areas, medical treatment, thermal pools:

5. Otopeni - Moesian Platform - heating houses and providing domestic water:

6. Baneasa . Press House - Moesian Platform - balneology.

Some geothermal water accumulations have a high combustible gas content: when the proportion of methane is 80-90%, this provides a combustible gas fraction of 1-2 $Nm^3/m^3$ of water, with a heating power of 8500 $kcal/m^3$. For more efficient and complete use of the geothermal energy available in such water, some consumers assisted directly hy FORADEX S.A. through measurements, studies and evaluations, have started to use the gas from geothermal water. To he mentioned are installations mounted in Salonta - Bihor, Sannicolau Mare and Teremia Mare - Timis, Arad and Timisoara (Geothermal Thematic map).

In order to obtain additional information on the already (1994) investigated fields. new wells have been sited and their drilling is under way in Santandrei area of the Pannonian Depression, where temperatures over 120°C are expected. Provided that a favorable result is obtained, it is intended to use the geothermal water for generating electricity in an ORC unit. The drilling and the production tests will he completed during 1995.

Within the Getic Depression, a well is being drilled in Olanesti area. The drilling has reached the final depth and preparations are made far the production tests. A temperature of 90-92°C is expected, as well as an artesian flowrate of 200 $m^3/h$, which is considered to be used for the heating of the hotels and of the recreation houses, as well as for balneology.

Within the Moesian Platform two wells are being drilled - one located in the northern extremity of Bucharest, that should check an hypothesis concerning the distribution of the hot sections within the Jurassic - Cretaceous reservoir, and another one in Snagov area, which. together with the first well drilled in its neighborhood, will form the geothermal doublet meant to provide 80-85°C water to the tourist dwellings of this resort.

Considered the outstandingly special therapeutic properties of the geothermal water in the north of Bucharest, also associated to a microclimate that is ideal for recreation and lo the pleasant landscape of the area, we expect Snagov resort to become an attraction for investments in tourism, recreation and health.

The results of these wells will hc known hy 1995.

## 4. DISCUSSION

At the time of the elaboration of the present paper, the geothermal sources in Romania are exploited by two state owned trade companies FORADEX S.A. and TRANSGEX S.A.

The design, the drilling and the completion, the reserves assessment and the feasibility studies for the use of the geothermal resources are performed by FORADEX S.A., which also prepares for the European Atlas of Geothermal Resources the papers concerning Romania.

The Institute of Geology and Geophysics in Bucharest includes a specialists team that elaborate general works concerning the geothermalism of Romania.

It can be observed that nowadays in Romania there doesn't exist a specialized organization dedicated to geothermal problems, to include geologists, geophysicists, thermists, physicists, reservoir engineers, that would elaborate a strategy on the future development of geothermics in Romania.

At the moment of the paper elaboration, the Romanian Parliament hadn't yet adopted the laws concerning oil, mineral resources, water resources, mines, or any other act regulating the exploration, the exploitation and the use of geothermal water.

The Romanian Constitution - adopted in 1991, stipulates that "resources of any nature occurring in the underground, the water with useful energy content, etc. are exclusively public property".

In October 1993 the National Agency for Mineral Resources (NAMR) of Romania was established, which has the mandate to manage the mineral resources belonging to the state, to negotiate the riders and the conditions of the agreements for mineral resources, to fix the taxes for geological exploration, the royalties and the prices for exploitation, to issue mandatory instructions concerning geologic exploration, the exploitation and the conservation of the mineral resources accumulations.

The NAMR also approves the establishment of the geological exploration, exploitation and accumulations conservation areas.

At the present time, the NAMR is the government agency that agrees upon the opportunity of performing geological exploration works, approves the amount of the financing to be provided for each exploration target, controls the accuracy of the performed work, decides whether the exploration or (and) the exploitation should be continued or halted if it estimates that it is not economic or if it has adverse effects on the environment, if it generates ecological desequilibria, if it proves hazardous to the population, etc.

All the geological exploration and exploitation works for geothermal resources are nowadays agreed upon, financed and followed up by NAMR.

## 5. CONCLUSIONS

FORADEX S.A. objectives for 1995 include the continuation of the investigation of the Jurassic - Cretaceous reservoir in the north of Bucharest and the start-up of the investigation of the Cainozoic volcanic formations in the Eastern Carpathians, by drilling and production tests.

Within the broad strategy of development and use of the identified geothermal resources, FORADEX will submit, in order to be agreed upon and financed, the projects and the studies indicated in TABLE 3 Appendix 4.

TABLES 4-13 (Appendix 5-14) include all available statistical data, concerning:

TABLE 4: Present and planned production electricity

TABLE 5: Utilization of Geothermal energy for electrical generation in December 1994

TABLE 6: Utilization of Geothermal energy for directheat in December 1994

TABLE 7: Summary table of Geothermal direct heat uses

TABLE 8: None use of Geothermal heat pumps

TABLE 9: Information about Geothermal localities

**TABLE 10:** Wells drilled for electrical and combined use of Geothermal resources from January 1, 1990 to December 31, 1994

**TABLE 11:** Wells drilled for direct heat utilization of Geothermal resources from January 1.1990 to December 31, 1994

**TABLE 12:** Total investments in Geothermal in (1994) US $.

Notice the outstanding financial effort dedicated to drilling wells, out of which only about 30% are used for direct heating-dwellings, greenhouses, industry, balneology, while the others are abandoned or stand-by, due to technical reasons or to the absence of interested consumers, as well as the low weight of electrical generation in the overall utilization of geothermal energy as a prospect for year 2000.

**Total investments**

In order to achieve our projects, we require the support of international organizations - both for conducting the studies, and for the acquisition of modern equipment and technologies, for efficient use of the energy of geothermal waters and for the building of tourist and balneological facilities that would benefit by use of this source of energy and health which abounds in the territory of Romania.

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## TABLE 4. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

| | Geothermal | | Fossil Fuels | | Hydro | | Nuclear | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Capa-city MW | Gross Prod. GWh/yr | Capa city MW | Gross Prod. GWh/yr | Capa city MW | Gross Prod. GWh/yr | Capa city MW | Gross Prod. GWh/yr | Capa-city MW | Gross Prod. GWh/yr |
| In operation in Jan.1995 | - | - | 16980 | 46000 | 5670 | 13000 | - | | 22650 | 59000 |
| Under construction in January 1995 | - | - | | | 230 | | 700 | | 930 | |
| Funds committed, but not yet under construction in January 1995 | - | - | | | | | | | | |
| Total projected use by 2000 | 2 | 16 | 15000 | 48000 | 5900 | 16000 | 1400 | 12000 | 22300 | 76000 |

## TABLE 5. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRICAL GENERATION IN DECEMBER 1994

[1] Data for 1994:

| Locality | Power Plant Name | Year Commiss. | No. of Units | Status | Type of Unit | Unit Rating MW | Total Installed Cap. MW | Annual Energy Prod.[1] GW/yr | Total under Constr. or Planned MW |
|---|---|---|---|---|---|---|---|---|---|
| Total | None | | | | | | | | |

## TABLE 6. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT IN DECEMBER 1994

[1] I = Industrial process heat; D = Space heating; S = snow melting; C = Air conditioning; B = Bathing and swimming; A = Agricultural drying; G = Greenhouses; F = Fish and other animal farming; O = Other (please specify by footnote)

[2] Enthalpy information is given only if there is steam or two phase flow

[3] Energy use (TJ/yr) = Annual average water flow rate (kg/s) x [Inlet temp.(°C)-Outlet temp.(°C)] x 0.1319

| Locality | Type[1] | Maximum Utilization | | | | | | | | Annual Utilization | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate | Temperature (°C) | | Energy use[2] TJ/yr | | | | | Aver. Flow Rate[**] | Energy Use[3] | Load Factor[***] |
| | | kg/s | Inlet | Outlet | I | F | D | G | B | kg/s | TJ/yr | |
| SATU MARE | DB | 12 P | 65 | 30 | 9 | | 15 | | 21 | 8 | 36 | 0.65 |
| CAREI | DB | 5 P | 45 | 25 | | | 2 | | 6 | 3 | 8 | 0.6 |
| ACÂŞ | G | 15 A | 65 | 30 | | | | 26 | | 6 | 26 | 0.38 |
| TĂŞNAD | DBG | 10 A | 70 | 35 | | | 6 | 14 | 17 | 8 | 37 | 0.75 |
| SĂCUIENI | DBGF | 22 A | 80 | 30 | 11 | 6 | 22 | 28 | 10 | 12 | 77 | 0.53 |
| MARGHITA | DB | 12 P | 65 | 25 | | | 21 | | 28 | 9 | 49 | 0.77 |
| MIHAI BRAVU | G | 6 A | 65 | 25 | | | | 13 | | 3 | 13 | 0.42 |
| BOGHIŞ | H | 12 A | 43 | 30 | | | | | 17 | 10 | 17 | 0.85 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BORȘ | G | 25 A | 118 | 35 | | | | 120 | | 11 | 120 | 0.44 |
| ORADEA | IDGB | 85 A | 83 | 30 | 51 | | 310 | 55 | 35 | 65 | 451 | 0.76 |
| ALEȘD | B | 3 P | 48 | 25 | | | | | 7 | 2 | 7 | 0.45 |
| LIVADA | FDB | 10 A | 88 | 30 | | 21 | 19 | | 7 | 6 | 47 | 0.62 |
| FELIX | B | 150 A | 45 | 30 | - | | | | 240 | 121 | 240 | 0.81 |
| MĂDĂRAȘ | B | 5 A | 46 | 25 | | | | | 7 | 2 | 7 | 0.45 |
| SALONTA | G | 7 A | 81 | 30 | | | | 26 | | 4 | 26 | 0.55 |
| CIUMEGHIU | FGB | 12 A | 92 | 35 | 12 | | | 23 | 8 | 6 | 43 | 0.48 |
| MACEA | FGB | 15 P | 65 | 25 | | 17 | | 22 | 8 | 9 | 47 | 0.6 |
| DOROBANȚI | GB | 15 P | 60 | 25 | | | | 32 | 4 | 6 | 36 | 0.52 |
| CURTICI | DGB | 22 P | 62 | 30 | | | 18 | 35 | 7 | 14 | 60 | 0.65 |
| IRATOȘ | IB | 12 A | 44 | 30 | | | 3 | | 7 | 6 | 10 | 0.47 |
| ȘOFRONEA | DB | 6 P | 41 | 25 | | | 3 | | 5 | 2 | 5 | 0.38 |
| ARAD | B | 12 A | 38 | 25 | | | | | 12 | 7 | 12 | 0.6 |
| NĂDLAC | IDB | 10 A | 75 | 25 | 16 | | 19 | | 8 | 6 | 43 | 0.65 |
| SÂNICOLAU | IDB | 50 A | 78 | 30 | 21 | | 175 | | 10 | 33 | 206 | 0.65 |
| SARAVALE | DB | 8 A | 75 | 30 | | | 18 | | 5 | 4 | 23 | 0.50 |
| TOMNATEC | G | 50 A | 77 | 25 | | | | 164 | | 24 | 164 | 0.48 |
| LOVRIN | DGB | 40 A | 78 | 30 | | | 95 | 50 | 20 | 26 | 165 | 0.65 |
| TEREMIA | IDB | 12 A | 85 | 30 | 5 | | 20 | | 10 | 5 | 35 | 0.40 |
| JIMBOLIA | IDGB | 55 A | 80 | 25 | 86 | | 135 | 35 | 7 | 36 | 263 | 0.66 |
| TIMIȘOARA | DB | 15 A | 42 | 30 | | | 6 | | 20 | 11 | 26 | 0.75 |
| HERCULANE | B | 75 A | 60 | 30 | | | | | 252 | 64 | 252 | 0.85 |
| OLT VALEY | DB | 22 A | 90 | 30 | | | 40 | | 82 | 15 | 122 | 0.70 |
| N. BUCHAREST | DB | 35 P | 60 | 25 | | | 72 | | 8 | 17 | 80 | 0.50 |
| Total | | 792 | | | 202 | 44 | 996 | 643 | 868 | 561 | 2753 | |

*) For TABLE 4 **) Max flowrate x load factor ***) Days in use /year

## TABLE 7 SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES

1) Inst. thermal power (MW) = Max. water flow rate (kg/s) x [Inlet temp.($^0$C) Outlet temp.($^0$C)] x 0.004184

2) Energy use (TJ/yr) = Annual average water flow rate (kg/s) x [Inlet temp.($^0$C)-Outlet temp.($^0$C)] x 0.1319

| | Installed Thermal Power[1] [MW] | Energy Use[2] [TJ/yr] |
|---|---|---|
| Space heating | 52 | 996 |
| Bathing and swimming | 39 | 868 |
| Greenhouses | 33 | 643 |
| Fish and other animal farming | 3 | 44 |
| Industrial process heat | 10 | 202 |
| Subtotal | | 35789 |
| Total | 1644 | 0 |

## TABLE 8 GEOTHERMAL HEAT PUMPS

1) Thermal energy used (TJ/yr) Annual average geothermal water flow rate (kg/s) x [Inlet temp.($^0$C)-Outlet temp.($^0$C)] x 0.1319

| Locality | Heat Source $^0$C | COP-Factor | Heat Pump Rating $Mw_t$ (Output) | Thermal Energy Used in Heating Mode[1] TJ/yr |
|---|---|---|---|---|
| Total | | | None | |

## TABLE 9 INFORMATION ABOUT GEOTHERMAL LOCALITIES

1) Main type of reservoir rock

2) Total dissolved solids (TDS) in water before flashing. put v for vapor dominated

3) N = Identified geothermal locality, but no assessment information available

R = Regional assessment F = Feasability studies (Reservoir evaluation and Engineering studies)

P = Pre-feasability studies U = Comunercial utilization

| Locality | Location To Nearest 0.5 Degree | | Reservoir | | Status[2] in Jan. 1995 | Reservoir Temp.(°C) | |
|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | Rock[1] | Dissolved Solids[2] mg/kg | | Estimated | Measured |
| SATU MARE | 47.48 | 22.53 | sand | 4000 | UP | | 88 |
| CAREI | 47.42 | 22.18 | sand | 6000 | U | | 90 |
| ACÂȘ | 47.55 | 22.47 | sand | 4600 | U | | 90 |
| TĂȘNAD | 47.29 | 22.35 | sand | 10976.9 | U | | 88 |
| SĂCUIENI | 47.21 | 22.06 | sand | 4500 | U | | 90 |
| MARGHITA | 47.21 | 22.21 | sand | 2500 | U | | 85 |
| MIHAI BRAVU | 47.16 | 21.57 | sand | 4500 | U | | 60 |
| BOGHIȘ | 47.09 | 22.44 | sand | 4200 | U | | 48 |
| BORȘ | 47.07 | 21.49 | limestone | 12000 | F | | 135 |
| ORADEA | 47.04 | 21.56 | limestone | 1200 | F | | 100 |
| ALEȘD | 47.04 | 22.24 | limestone | 5000 | U | | 52 |
| LIVADA | 47.03 | 21.50 | limestone | 1200 | U | | 107 |
| FELIX | 47.00 | 22.01 | limestone | 800 | U | | 44 |
| MĂDĂRAȘ | 46.50 | 21.42 | sand | 1600 | U | | 62 |
| SALONTA | 46.48 | 21.41 | sand | 3200 | F | | 95 |
| CIUMEGHIU | 46.44 | 21.35 | sandstone | 4000 | F | | 120 |
| ZERIND | 46.38 | 21.32 | sandstone | 6200 | R | | 98 |
| MACEA | 46.24 | 21.19 | sand | 2100 | U | | 72 |
| DOROBANȚI | 46.22 | 21.15 | sand | 2500 | U | | 74 |
| CURTICI | 46.21 | 21.19 | sand | 2100 | U | | 65 |
| IRATOȘ | 46.19 | 21.12 | sand | 1812 | U | | 64 |
| ȘOFRONEA | 46.17 | 21.19 | sand | 1400 | U | | 70 |
| ARAD | 46.11 | 21.19 | sand | 1400 | UP | | 42 |
| NĂDLAC | 46.10 | 20.45 | sand | 2400 | U | | 84 |
| SEMLAC | 46.07 | 20.56 | sand | 2500 | U | | 65 |
| SÂNICOLAU MARE | 46.04 | 20.35 | sand | 3100 | UF | | 88 |
| SARAVALE | 46.04 | 20.45 | sand | 2400 | UP | | 90 |
| PERIAM | 46.02 | 20.53 | sand | 2000 | R | | 80 |
| VARIAȘ | 46.01 | 20.58 | sand | 1400 | U | | 65 |
| TOMNATEC | 45.59 | 20.40 | sand | 3600 | U | | 84 |
| LOVRIN | 45.58 | 20.46 | sand | 2700 | U | | 91 |
| TEREMIA MARE | 45.56 | 20.31 | sand | 2800 | UP | | 90 |
| COMLOȘU MARE | 45.54 | 20.37 | sand | | R | | 85 |
| GRABĂȚ | 45.52 | 20.48 | sand | | R | | 88 |
| LENAUHEIM | 45.52 | 20.48 | sand | 9500 | RP | | 82 |
| JIMBOLIA | 45.48 | 20.43 | sand | 2800 | U | | 88 |
| BERECSĂU MIC | 45.46 | 21.01 | sand | | R | | 77 |
| TIMIȘOARA | 45.45 | 21.14 | sand | 12000 | U | | 60 |
| HERCULANE | 44.50 | 22.30 | limestone | 4500 | U | | 70 |
| OLT VALEY | 45.16 | 24.20 | siltstone | 12000 | U | | 98 |
| OTOPENI | 44.33 | 26.07 | limestone | 2200 | UF | | 66 |

## TABLE 10. WELLS DRILLED FOR ELECTRICAL AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 1990 TO DECEMBER 31, 1994

(Do not include thermal gradient wells less than 100 m deep)

[1] Type or purpose of well

T = Thermal gradient or other scientific purpose — P = Production

E = Exploration — I = Injection — C = Combined electrical and direct use

[2] Total flow rate at given wellhead pressure (WHP)

| Locality | Year Drilled | Well Number | Type of Well[1] | Total Depth m | Max. Temp. °C | Fluid Enthalpy kJ/kg | Well Output[2] estimated | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Flow Rate kg/s | WHP bar |
| Sântandrei | 1994[*] | 1720 | E | 3500 | 150[**] | | 50 | 5 |

[*] To be finished in 1995 [**] BHT

## TARLE 11. WELLS DRILLED FOR DIRECI IIEAT UTILIZATION OF GEOTIIERMAI. RESOURCES FROM JANUARY 1, 1990 'IO DISCEMBER 31,1994

(Do not include thermal gradient wells less than 100 m deep)

[1] 'Type or purpose of well and manner of production
Use one symbol from column (a) and one from column (b)

(a)
T = Thermal gradient or other scientific purpose
E = Exploration
P = Production

(b)
I = Injection
C = Combined electrical and direct use
A = Artesian
P= Pumped
F = Flashing

[2] Total flow rate at given wellhead pressure (WHP)

| Locality | Year Drilled | Well Number | Type of Well[1] | Total Depth m | Max. Temp. °C | Fluid Enthalpy kJ/kg | Well Output[2] estimated | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Flow Rate kg/s | WHP (bar or m) |
| SATU MARE | 1990 | 4750 | E, P | 1460 | 67 | | 3.6 | -75 m |
| PERIAM | 1990 | 4627 | E, A | 1400 | 58 | | 10 | - |
| VIDELE | 1990 | 1 V | E, P | 2231 | 40 | | 8 | -96 m |
| OTOPENI | 1990 | 2672 | E, P | 3204 | 72 | | 20 | -60 m |
| MOARA VLĂSIEI | 1990 | 2676 | E, P | 3028 | 76 | | 24 | -40 m |
| BUFTEA | 1990 | 2679 | E, P | 3202 | 40 | ABAND. | 0.7 | - |
| ÎNSURĂȚEI | 1990 | 2107 | E, A | 1551 | 60 | | 8 | 1 bar |
| SEMLAC | 1991 | 1683 | E, P | 1462 | 55 | | 6 | -34 m |
| AVITIM | 1991 | 1189 | E, P | 1304 | 51 | | 4 | -30 m |
| COVACI | 1991 | 1190 | E, A | 1451 | 53 | | 2.5 | - |
| SNAGOV | 1991 | 2682 | E, P | 3273 | 83 | | 20 | -36 m |
| BALOTEȘTI | 1991 | 2669 | E, P | 3304 | 74 | | 28 | -40 m |
| MOARA VLĂSIEI | 1991 | 2680 | E, P | 2829 | 78 | | 35 | -40 m |
| CĂLIMĂNEȘTI | 1992 | 1009 | E, A | 3250 | 91 | | 28 | 6 bar |
| SNAGOV[**] | 1994 | 2683 | E, P | 3200 | | | | |
| AVIAȚIEI[**] | 1994 | 2642 | E, P | 2100 | 60 | | 20 | -60 m |
| OLĂNEȘTI[**] | 1994 | 1007 | E, A | 3000 | | | | |
| Total | | | | | | | | |

[*] Wellhead temperature

[**] Drilling to be completed in 1995

## TABLE 12. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with a University degree)

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

| Year | Professional Man Years of Effort | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6)[*] |
| 1990 | 6 | 10 | 7 | | | 25 |
| 1991 | 2 | 3 | 6 | | | 20 |
| 1992 | 2 | 3 | 6 | | | 18 |
| 1993 | 2 | 4 | 4 | | | 16 |
| 1994 | 2 | 5 | 5 | | | 15 |

[*] State companies (FORADEX S.A. & TRANGEX Cluj)

## TABLE 13. TOTAL INVESTMENTS IN GEOTIIERMAL IN ( 1994) US $

| Period | R & D Include. Surf. Exp. & Exp. Drilling Million US $ | Field Development Incl. Prod. Drilling % Surf. Equipment Million US $ | Utilization | | Funding type | |
|---|---|---|---|---|---|---|
| | | | Direct Million US $ | Electrical Million US $ | Private % | Public % |
| 1975-1984 | 99 | 50 | 50 | | - | 100 |
| 1985-1994 | 36 | 12 | 12 | | - | 100 |